

**Government of Saint Lucia
Ministry of Planning and Development**

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**Watershed and Environmental Management Project
Phase II**

Final Report
October 1998

Main Report

Hunting Technical Services
Hemel Hempstead
England

In association
with

Mott MacDonald Limited
Cambridge
England

Under assignment to the Department for International Development, UK

Hunting Technical Services Limited
 Thamesfield House
 Boundary Way
 Hemel Hempstead
 Hertfordshire HP2 7SR
 United Kingdom
 Tel +44 (0)1442 231800
 Fax +44 (0)1442 219886
 Email: hts_uk@compuserve.com

26 October 1998

The Permanent Secretary
 Ministry of Finance, Planning, Information
 Services and Public Services
 Government Buildings
 CASTRIES

Dear Sir,

Watershed and Environmental Management Project
Phase 2 - Final Report

I have pleasure in submitting this, our Final Report for the Watershed and Environmental Management Project - Phase 2.

The report follows 29 months of consultancy provided by a Team Leader- Agriculturalist, Socio-Economist, River Engineer, Land Use Planning and Environmental Specialist, Institutions/Legislation Specialist, Geotechnical Engineer and Landslide Hazard Mapping Specialist. The team was supported by a Project Adviser and Geotechnical Adviser during the early stages, and through the good offices of BDDC, the Supervising Engineer from Phase 1 was made available for two weeks to facilitate a good start to the work.

We are sending ten copies of the Report, to allow for internal distribution, previous reports being:

- Inception Report - October 1996
- Draft Technical Reports - December 1996
- Progress Report - January 1997
- Interim Report - March 1997
- Progress Report - September 1997
- Draft Final Report and Technical Annexes - November 1997

We are also sending five copies of the Report to the BDDC.

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On completion of the final consultancy period, it was mutually agreed between Government, BDDC and the Consultants, that following the circulation and technical assessment of the draft report, a Presentation Seminar be convened in St Lucia. This seminar took place on 27 July 1998 and was attended by the Honourable Prime Minister of St Lucia, Permanent Secretaries and Senior Government Technical Staff and representatives of: the World Bank (who funded Phase 1), BDDC (who funded the Phase 2 study), the Caribbean Development Bank, OECS and a two man team from Hunting Technical Services Ltd.

The seminar afforded an opportunity to comment in detail on the draft report and the development proposals contained therein. The final report takes cognisance of the overall response and proceedings of the seminar are included as Appendix C to this report.

The Draft Report was submitted as a Main Report with twelve technical annexes in three separate volumes. The annexes have not changed for the Final Report and they will not be distributed again. However, we will be happy to supply further sets if they are requested.

The Main Report, while drawing on the Technical Annexes, is written in sufficient detail to be self standing. It covers all the main issues starting with some introductory text to set the scene, examines the background to environmental problems and Government's present stance. A description of the Island's physical and economic characteristics follows after which environmental issues are examined in detail. After reviewing agriculture and the possibilities of diversification, Chapter 6 sets out the rationale and plans for the two pilot watersheds, Dennery and Cul de Sac, and this is followed by an examination of the replication process, island wide. Chapter 8 puts figures to the plan and the final chapter makes recommendations regarding possible grant aid.

It is sincerely hoped that you and other government staff will find the report interesting, comprehensive and realistic in terms of its developmental objectives.

Yours faithfully,



J.F. Morton

Director, Latin America and The Caribbean

ACKNOWLEDGEMENTS

The Consultants wish to express their gratitude to the Government of St. Lucia, to the ordinary people with whom they have had contact, and the staff of the British Development Division in the Caribbean. From the outset, the team was treated with friendly openness which allowed productive working relationships to develop.

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Within AESD, Mr Martin Satney, the Project Co-ordinator until 1997 deserves special mention for his guidance, enthusiasm and energy; and subsequently to Mr Felix Jaria who inherited the position. By the same token our thanks go initially to Ms Rufina Charlery - Ministry of Planning Co-ordinator and later Mr Michael Gittens who took on the task with enthusiasm.

Others with whom the team had regular contact and without whom our work would not have been possible were: Mr David Louis of MCWT&PU, Mr Rodney Soomer, Chief Economist in the Ministry of Planning who stood in at short notice on important meetings and Ms Liz Lewis-Charles, GIS Specialist.

Thanks also to the staff of the many Ministries and Institutions with which we had contact, SLBGA, WIBDECO, ADCU, IICA, OECS, CEHI, to name but a few.

This acknowledgement cannot be complete without mentioning the WMAF in Dennery where a far reaching community participation was conducted. The Committee, Edme Celestine, Alfred Prospere, Rosiland Felix and Jerome Gideon deserve special thanks for their contribution to the project and the nation.

And finally to Mr Brian James the Chief Forest and Lands Officer and his staff who provided not only an office, but a friendly environment in which to work and to our staff of two drivers and a secretary who were willing to do anything at any time , and with a smile.

Our warm thanks to everyone concerned.

ACRONYMS AND ABBREVIATIONS

ACP	African, Caribbean and Pacific
AESD	Agricultural Engineering Services Division (of MAFF&E)
ADCU	Agricultural Diversification Coordinating Unit
API	Aerial Photography Interpretation
BDDC	British Development Division in the Caribbean
CAMMA	Canaries and Anse La Raye Marine Management Area
CANARI	Caribbean Natural Resources Institute
CAP	Chapter of GoSL Legislation
CARDI	Caribbean Agricultural Research and Development Institute
CBO	Community Based Organization
CEHI	Caribbean Environmental Health Institute
CIDA	Canadian International Development Agency
CPC	Community Participation Candidate
CPP	Community Participation Programme
CRM	Coastal Resource Management
CZM	Coastal Zone Management
CZMU	Coastal Zone Management Unit
DCA	Development Control Authority (of MP&D)
DFID	Department for International Development (UK)
EC\$	Eastern Caribbean Dollars
EEZ	Exclusive Economic Zone
EH	Environmental Health
EIA	Environmental Impact Assessment
ENCORE	Environmental and Coastal Resource Project
EU	European Union
FAO	Food and Agricultural Organization (of UN)
GATT	General Agreement on Tariffs and Trade
GIS	Geographical Information System
GoSL	Government of St. Lucia
GTZ	German Technical Mission for Co-operation
HTS	Hunting Technical Services
ICZM	Integrated Coastal Zone Management
IFAD	International Fund for Agricultural Development
IoH	Institute of Hydrology (UK)
ISM	Island System Management
LCB	Land Conservation Board
LUT	Land Utilisation Types
LCDC	Land Development and Drainage Committee
MAFF&E	Ministry of Agriculture, Forestry, Fisheries and Environment
MCWT&PU	Ministry of Communications, Works, Transport and Public Utilities
MFPIS&PS	Ministry of Finance, Planning, Information Services and Public Services
MHHSFA&W	Ministry of Health, Human Services, Family Affair and Women
MM	Mott MacDonald
NEAP	National Environmental Action Plan
NEC	National Environmental Commission

NEMO	National Emergency Management Organisation
NGO	Non-Governmental Organisation
NRMU	Natural Resource Management Unit (of OECS)
OAS	Organisation of American States
OCDP	Orchard Crop Diversification Project
OECS	Organisation of Eastern Caribbean States
PM	Prime Minister
PPU	Physical Planning Unit (of MP&D)
PS	Permanent Secretary of GoSL Ministry
RMU	River Management Unit
SFAD	Small Farmer Development Project
SFAP	Small Format Aerial Photography
SI	Statutory Instrument of GoSL Legislation
SLAA	St. Lucia Agriculturalist Association
SLBGA	St. Lucia Banana Growers Association
SLNT	St. Lucia National Trust
SMMA	Soufriere Marine Management Area
SWM	Solid Waste Management
TDB	Tourist Industry Development Board
TOT	Technical Operations Team
ToR	Terms of Reference
TRoPRo	Tropical Produce Support Project
TSD	Tropical Storm Debbie
USAID	United States Agency for International Development
USDA	United States Development of Agricultural
UWI	University of the West Indies
WASA	Water and Sewerage Authority
WIBDECO	Successor to WINBAN
WINBAN	Windward Island Banana Growers Association
WMAF	Watershed Management Action Force
WMO	World Meteorological Organisation
WMU	Watershed Management Unit
WTO	World Trade Organisation
WWF	World Wildlife Fund

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LUCIAN HOTEL 27 JULY 1998**

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

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1 INTRODUCTION

Over the years the environment of St Lucia has increasingly suffered from misuse. Natural forest cover on the steep hillsides has been removed to make way for bananas, feeder roads have been constructed to support this development, and uncontrolled building in inappropriate places have all contributed to the deterioration. The results are seen in an increase in flash floods, very low base flows in the river system during dry seasons, and massive soil loss due to erosion. This in turn has caused siltation of the valley floor drainage system and allowed large quantities of silt to be deposited in the sea, spoiling coral reefs and detracting from the beauty of the many beaches used by tourists.

Little regard has been shown by Government and the population alike, and it took a storm of the intensity of Tropical Storm Debbie (TSD) to force an awareness that the island was facing a serious environmental crisis. In the immediate aftermath of the storm the environment was high on the agenda; but subsequently, apathy has returned and little real action has occurred.

The Watershed and Environmental Management Project, proposed by the World Bank consultants in the immediate post-TSD period, was designed, through a series of scientific investigations, to propose a strategy for the sustainable management of the Island's 37 watersheds. This report strongly promotes a proactive rather than the prevailing reactive approach, and presents a programme which, if developed, will start St Lucia on the slow road to environmental recovery.

2 TROPICAL STORM DEBBIE

Environmental degradation is a slow insidious process, and little concern was evident until Tropical Storm Debbie (TSD) hit St Lucia on 10th September, 1994. The storm followed a period of high antecedent rainfall when soils were at field capacity, and it deposited up to 15 inches of rainfall (370mm) in some areas over a 10 hour period. The resulting massive landslides, around 400 in number, together with rapid run-off transporting soil, debris and solid waste, caused extensive flooding and severe damage to infrastructure. The flood caused four deaths, 24 injuries, destroyed homes and disrupted electricity and water supplies. Damage to infrastructure was estimated at between EC\$50-60 million and losses to the agricultural sector some EC\$150 million.

While TSD was the prime cause of the damage, the severity was undoubtedly exacerbated by the reduced forest cover, wrong land use and the poor maintenance of on-farm and public works due to inadequate maintenance allocations. This event brought into sharp focus the need for Government to take a more proactive approach.

Following the storm, Government was quick to respond, establishing emergency water supplies to 80% of the population, installing temporary bridges, clearing roads and cleaning critical sections of river channels. At the same time a request was made to the World Bank for assistance. A Mission was fielded in November/December, 1994, which proposed a two-stage strategy.

3 PHASE 1

Phase 1 comprised a priority works programme to effect repairs to the rivers and drainage systems. This was costed and a loan of EC\$ 14.3 million was agreed with the World Bank. The British Overseas Development Administration (ODA) agreed to fund the technical assistance component and a supervising engineer arrived in February, 1995. The Phase 1 works were largely completed by May, 1996.

There was a degree of urgency in completing the works before the next wet season.

As part of their TOR, the Consultants were asked to review Phase 1 works but this was hampered by damage to the new works that took place during a subsequent severe storm on 26th October 1996. Phase 2 Consultants had just started their consultancy contract and had undertaken some of the field assessments related to the rehabilitation work when the severe flood flows took place, particularly over the central part of the island, causing further damage to the existing and new works. Significant further damage took place in the Cul de Sac, Roseau, Troumassee, Castries, Canelles and Soufriere Watersheds although other watersheds were also affected. However, lessons learned from the review, both from an engineering and environmental aspect, have been taken into account in the Consultants' approach to Phase 2.

4 PHASE 2

Phase 2 was designed to take a longer term view of environmental management in order to achieve sustainable development of land and water resources through watershed management. The consultancy was funded by BDDC who together with the GoSL had prepared a project Document based on the original World Bank concept. The Main focus of the consultancy was:

- collation of existing data on watershed management programmes in St Lucia, identification of problems experienced and solutions applied and their relative degree of success;
- identification and field testing of solutions to unsolved problems (eg flood hazard planning, landslide / slope stabilisation, sustainable land use, river stabilisation, social impact, conservation of biodiversity and the environment), disaster preparedness and management;
- review of existing institutional infrastructure and legislation for integrated watershed management, identifying necessary human resource development; recommendation of legislative reform to enhance effectiveness and efficiency, including powers and means of enforcement;
- on the basis of the above, design and implementation of pilot watershed management plans for two selected sites; design of a strategy for extrapolating pilot site results to the whole island on a watershed basis.

This involved 29 months of consultancy, provided by a Team Leader / Agriculturist; Socio-economist; River Engineer; Land Use Planner & Environmentalist; Geotechnical Engineer; Institutions / Legislation Specialist and Landslide Hazard Mapping Specialist. The team was supported by short inputs from a Project Adviser (ex-World Bank Team), a Geotechnical Adviser, and the Phase 1 Supervising Engineer.

Project design was a two-stage approach, with a six month interval between the two series of inputs.

The Consultancy took place between the beginning of September, 1996 and the end of November, 1997.

5 BACKGROUND

The island of St Lucia is characterised by steep topography, deeply incised valleys, heavy rainfall and short river runs. Rainfall varies from 1450mm (57 inches) at Hewanorra in the south to 3450mm (136 inches) at Edmund Forest. The main river systems number 37 and the island thus subdivides into these 37 watersheds. Agriculture predominates, with a recorded 51,328 acres out of a total landmass of 152,214 acres (33.7%) under cultivation. Many of the environmental problems are being caused by uncontrolled cutting of the natural forest and the planting of bananas on this steep land. Other contributory causes are an ill-thought out feeder road programme and uncontrolled building for domestic purposes.

The population has been growing steadily over the years, and it is currently estimated at 150,977. The annual growth is 1.9%, which in the absence of any significant out-migration, would lead to a doubling of the population in less than 40 years. Population density averages 635 per square mile, around two thirds rurally based. 65% of the population is under 30 years of age.

Growth in the economy has been falling since 1990 when it was estimated at 3.9%. Current estimates for 1997/98 are as low as 1%. Gross National Product was estimated at US\$ 501 million in 1994, giving a per capita figure of US\$ 3450, or EC\$ 9315. The GDP share of the tourism sector, measured by hotels and restaurants, increased from 8.4% in 1977 to 11.7% in 1995. The contribution of agriculture (mainly bananas for export) declined in the period 1977-95 from 17.5% to 11.2%. Government Services still provide a large share of the GDP with 13.6% in 1995. The share of the manufacturing sector fluctuated somewhat, increasing from 6.3% in 1977 to as much as 9% in 1987 before falling to 7% in 1995. The development of the country's physical infrastructure resulted in the steady growth of the construction sector from 4.4% (1977) to 8.5% (1995) of real GDP. Other important sectors of the economy are transport and communication (18%), wholesale and retail (13%) and banking and insurance (10%).

The employed labour force is distributed as follows: 25% agriculture; 12% manufacturing; 12% trade; 9% construction; 8% tourism; and 34 % in other services. The unemployment rate has gradually increased over the years and is currently estimated at 20% island-wide, with record heights between 32% and 35% for the districts of Anse La Raye, Choiseul and Laborie. The proportional contribution of the 15-19 year age group to the employed labour force is 7% whereas their share of the unemployed labour force is 27%. About 55% of the unemployed labour force is below 24 years of age.

Adult literacy is estimated at 82%, but only 1.6% of the population attained university education. Fifty three percent complete only primary school, 15% secondary school and there is a recognised deficiency in school places. There is a net shortage of skilled labour, but prospects for the unskilled unemployed are poor.

The economy is dominated by bananas. The industry together with ancillary support sectors accounts for one job in three of the total employed population. In 1995 banana exports were EC\$ 128.1m or 47% of total export earnings. Any problem within the banana industry quickly reverberates to all sectors of the economy, and has on occasions led to social unrest.

6 THE GOVERNMENT RECORD

Over the years there have been many attempts to redress the growing environmental problems, but government has failed to find the political will to implement plans.

There has been a tendency for GoSL to take environmental issues seriously following serious flood events such as (TSD) in the face of ample evidence of damage and then, in time, the more visible infrastructure, health or social problems make prior demands on available Government resources. The pattern of neglecting the environment during less catastrophic times, is illustrated by the following:

- an Environmental Commission was first established in 1981, but faded away for lack of political support, only to be re-launched in June 1995 after TSD;
- the National Environmental Commission, the organisation now charged with overall responsibility for management of the environment has still not been nominated and has yet to hold its first meeting although a National Environmental Action Plan (NEAP) has been agreed;

- Land Conservation legislation was first proposed in 1984, the draft Bill became available by the end of 1987 and the Act finally reached the statute books in April 1992;
- the Land Conservation Board (LCB) was finally appointed in 1995, again after TSD and met for the first (and only) time in November 1995;
- no LCB regulations have been formulated and the Board has no access to funds.

Budgetary constraints have limited the capacity of the MCWT&PU to adequately maintain the river and drainage system and have concentrated their efforts on road building and maintenance. This, in an average year, has caused problems to the banana growers in the fertile valley bottoms, and the industry has suffered as a result, with dire consequences to the country's economy. The World Bank Mission (1994) remarked.

While TSD was the prime cause of damage, the situation was undoubtedly exacerbated by poor maintenance of both on-farm and public works prior to the deluge. This was the result of insufficient budget allocations to those departments responsible for government interventions, together with poor management and inadequate expenditure control. Furthermore, the excessive displacement of silt in many watersheds was the direct result of government's failure to control the expansion of cultivation into forests and on overly steep slopes.

With the exception of the emergency works, which formed Phase 1 of the WEMP, the problem of inadequate budgetary allocations has persisted.

7 THE CONSULTANCY STUDIES

7.1 The TOR were broad in content and very demanding. Starting with a review of Phase 1, from both an engineering and an environmental perspective, studies covered a multitude of topics as may be expected in a subject as all-embracing as environmental management. Full details of the studies form the series of Technical Annexes, published in Volumes 2, 3 and 4 and only a very brief summary is presented here.

7.2 An exercise of agro-ecological zoning was undertaken (Annex 4), involving analyses of rainfall and evapotranspiration data, and calculation of deficits and surpluses. Six agro-climatic zones (A to F) were defined, spanning the range from 4000mm mean annual rainfall with no dry months, to 1500mm with 8 Dry (of which 6 very dry) months. The important aspect of rainfall intensity, the cause of major flooding, was also examined, many stations showing rates in excess of 80mm/hour for more than 1.5 hours, and 6-hour rainfall in excess of 250mm.

7.3 An analysis of soils was also undertaken, with mineralogical and depth classes then being combined with the agro-climatic zoning to give the agro-ecological zones, mapped at 1:100,000 scale. Superimposing slope ranges on this would give detailed zoning, but would require mapping at 1:10,000. Suitability ratings for the major crop types were then assigned to each of the agro-ecological zones, according to FAO 'Framework for Land Evaluation' methodology. Special attention was given to soil infiltration rates, another key factor related to flooding. Field trials demonstrated that on banana land, the presence of a uniform cover of banana trash increased infiltration rates by a factor of 100% and clearly banana trash management is crucial to successful watershed management.

7.4 Existing landuse mapping and data was reviewed. The Consultants had serious reservations regarding the use of satellite imagery for such mapping, and air photography of the last 15 years covered little of the pilot areas. Small Format Air Photography (SFAP) using a helicopter was thus undertaken at 1:4500 and 1:7500 scales. However, due to weather and logistics factors, this was done

too late in the assignment for routine mapping to be undertaken for the entire area of the pilot watersheds. Nevertheless, mapping (at 1:7500 scale) for two areas in Cul de Sac showed the usefulness of the technique in detailing areas of soil erosion and other environmental problems. Banana and other crop areas could be mapped with great precision using this technique.

7.5 Meteorological and stream flow data for the island was reviewed (Annex 2), revealing very serious deficiencies prior to TSD. However, a substantial amount of equipment has now been installed, notably some 26 tipping-bucket-type rainfall recorders, and staff were trained in their use and maintenance. Data on streamflows was shown to be even more deficient, and to date this has not been rectified. Designs were made for the river gauging stations, and sites earmarked for these. Gauging for both peak flood flows, and dry season base flows urgently needs to be undertaken. Updated Hydrological Database and processing software (HYDATA) was provided by the project to AESD staff, including staff training.

7.6 Flood mapping at 1:2500 scale was undertaken for all the floodplain areas as an additional 2-month assignment under the Project, and flood reports completed for all areas for both TSD and the 26 October 1996 flood events. The experience of the floods of 26 October (and less severe flooding of 11th November) proved to be very valuable in demonstrating the relative severity of flooding in different areas in relation to rainfall, and in showing infrastructure and Phase 1 activities under threat. Calculations on flood flows were made for both events from the main watersheds, and these were compared to expected flooding levels from the recorded rainfall intensities (Annex 3).

7.7 Landslide Hazard Mapping and Mapping of Landslides associated with TSD were reviewed and updated (Annex 6). Slope mapping undertaken on the Ministry of Planning GIS was reviewed, and reservations expressed on the accuracy and suitability of this information. Land Use Mapping at 1:10,000 scale also was not available, and thus Landslide Hazard Mapping at this scale could not be undertaken. However, procedures were listed for undertaking this work.

7.8 Field Trials undertaken by the Consultants included Agronomic, Community Participation, Engineering, Bio engineering and Geotechnical Engineering Trials (Annex 7).

Agronomic Trials were undertaken on steeply sloping banana land, at two different locations in Dennery and two in Cul de Sac. These focused on practical soil conservation measures in typical smallholder farmers' fields, notably trash management and trash lines, and demonstrated very clearly the benefits of trash in increasing soil infiltration rates (and thus reducing run-off from high rainfall events).

Engineering Trials covered river maintenance at Dennery, and gabion and mac-mat protection of river banks at Cul de Sac. Implementation of these was achieved to a high standard. Use of a filter cloth backing to the gabion work was also incorporated, and proved to work well. Cost of such measures however, is justified only for protection of expensive infrastructure (major roads) and not for agricultural land. Other trials planned by the Consultants were not implemented because the works capacity of MCWT&PU was the limiting factor.

Bioengineering trials were undertaken at Mahaut and Combat involving some 12 tree species and achieved variable success.

A Landslide Hazard Warning System trial was installed in the Chopin Ridge-Ravine Poison area of Cul de Sac at 5 sites. This comprised standpipe piezometer and slope inclinometer installations in areas which appear unstable (steep slopes, adjacent landslide scars). Holes were drilled to depths of 12 to 21 m into more stable underlying materials. Inclinometer measurements were continued through the period, but due to a much drier wet season, no significant movements were recorded. Measurements would be undertaken at monthly intervals in the dry season, increasing in frequency to daily measurements during prolonged wet periods. Local residents would be alerted if significant movements were recorded.

8 THE MAIN FINDINGS

The main findings are set out as a prescription for improved watershed and environmental management:

8.1 AGRICULTURAL LAND, PRODUCTION, AND PRACTICES

a) Major emphasis must be placed on soil conservation, particularly in banana lands. This emphasis should include:

- optimal trash management to protect entire soil surfaces;
- stakes closely spaced on the contour to retain trash (trash-lines);
- tied contour drains (careful management required on steeper slopes and landslide-risk areas);
- better design of vertical drains, with bio-engineered controls;
- integration of path / track drainage with field drainage.

Work on the banana land should be the responsibility of the SLBGA staff, and criteria for certification of sloping land should include trash management. Any future project would seek to finance up to 5 SLBGA officers to work full time on soil conservation extension and certification. This would be through a grant to the SLBGA from the LCB who would monitor progress of soil conservation improvements.

It is reassuring that the Banana Certification Programme by WIBDECO/SLBGA is proceeding at a promising pace, and could in the near future be used as the major mechanism for improving soil conservation on steeply sloping banana lands.

The existing MAFF&E Extension Service should be strengthened to undertake soil conservation extension work on other crops.

b) Encouragement should be given to farmers to re-plant banana areas to permanent treecrops in sensitive areas, vis:

- at ridgetops, and within 100m of ridgetops,
- on land of >30 degrees slope,
- on landslide-risk areas, irrespective of slope.

On steep slopes, planting of some permanent treecrops within existing bananas should be encouraged, leading to gradual replacement of some bananas by treecrops. Top priority should be given to banana land of over 30 degrees slope, comprising some 1900 acres (760ha), followed by land of 25-30 degrees slope (2500 acres - 1000ha). Any future project should make planting material available to farmers, together with fertiliser inputs and technical advice. To compensate for loss of income in years 2-5 farmers would be encouraged to take loans through the local credit unions, to whom the project would extend soft loan money on a revolving basis. Alternative crops to be immediately promoted would include Julie Mango, Breadfruit, Avocado, Sweet Orange and Cocoa.

c) Prohibition of clearing of **new** agricultural holdings on forest land should be enforced, particularly in the following cases:

- at ridgetops, and within 100m of ridgetops;
- on land of >30 degrees slope;
- on landslide risk areas, irrespective of slope.

Prohibition should be backed up by public education, involving the media, the agricultural extension service, schools, churches, police, and coordinated through the local Watershed Management Action Forces (WMAFs).

d) Felling of any perennial trees on slopes of >25 degrees should be prohibited, these trees being the best guarantee that the land on which they stand will not be subject to landslides.

e) Bans should be enforced on the cultivation of land above WASA water intakes.

f) A major effort should go into the co-ordinated marketing of treecrop products, using

- existing banana boat transport and marketing channels in the UK;
- inter-island trade (particularly to Barbados & Trinidad);
- air freight, particularly to the UK, Canada, and Europe.
- local tourist hotels, cruise ship and yacht suppliers.

MAFF&E would be strengthened to improve publicity and information services. Produce would include commonly exported produce such as mangoes, avocados, bread-fruit, guava, golden apple, cashew and soursop.

Trials would be undertaken on new treecrops, particularly rambutans, mangosteens, jakfruit, durian.

g) Some alluvial lowlands, particularly in the most flood-prone areas, could be considered for alternative seasonal crops, or crops more tolerant of flooding or waterlogging, eg dasheen.

h) Under-utilised lands of less than 10-15 degrees slope should be available for agricultural use by suitable landless smallholders. The Land Taxation mechanism could be employed to encourage land owners to use such land to full potential. A Land Bank Programme should be considered to facilitate agricultural use of such land.

i) The decline in the coconut industry, and the current felling of coconut trees, gives major cause for concern. Coconut trees are extremely useful in binding the soil in many banana plantations. A major effort is required so that the decline in this important, and eco-friendly crop, is reversed. The recent re-opening of Soufriere factory is to be welcomed, and it is in everyone's interest that the purchasing of coconuts is resumed as quickly as possible.

8.2 FORESTRY

a) Forest buffer zones should be extended into existing agricultural areas in landslide-risk areas.

b) The 20-metre river reserve should be rigorously enforced. Mixed perennial treecrops and some timber species should be encouraged. Radical pruning of older trees should be discouraged.

c) The excellent work of the Forestry Department in education and public awareness should be further encouraged, including the introduction and planting of a wider range of forest species, both indigenous and exotics. The Jak-fruit (*Artocarpus heterophyllus*) deserves promotion, as this is useful as a fruit, a vegetable, and is an excellent timber tree.

8.3 LANDSLIDE-RISK, AND FLOOD-RISK AREAS AND ZONATION

a) Landslide Risk

A major emphasis on public education should be targeted for the worst landslide-risk areas (eg Ravine Poisson), and the highest-risk areas should be rezoned for permanent tree cover. High risk areas are those where the following characteristics coincide:

- steep slopes (all areas of >35 deg, most of 30-35 deg. and some of 25-30 deg),
- high intensity rainfall (see Fig 1.3 in Annex 4),
- areas of concavity (influx of water)
- absence of deep taproots of perennial trees;
- deep soil (particularly >200cm).

Human interventions such as cuts into the slope for roads or houses, or further cultivation of the slope, only increase the landslide risk.

New building should be carefully vetted in landslide-risk areas. This includes building on private land as well as public building and roads.

In the highest risk areas, the WMAF in association with the Disaster Preparedness Committee should warn local people during periods of very high risk, ie when hurricanes or tropical storms are forecast at times when soils are already at field capacity. Temporary relocation in safe nearby buildings (eg schools) could be provided for people during these relatively short periods. Local committees could also be more involved in undertaking inclinometer-type monitoring of very high risk areas, particularly on an daily or hourly basis during high risk periods.

Rapid replanting of landslip materials and exposed river banks to cover-crop species should be carried out. Landslips on private land, misused for cultivation, should be planted to permanent treecrops.

b) Flood Risk

Floods in St Lucia are always flashy and are over within 6 hours or so. Coastal towns and villages, invariably built adjacent to river mouths, have an additional hazard of storm tides and surges increasing water levels during many cyclone-induced flood periods. Periods of high flood risk coincide with periods of high landslide risk: Disaster Preparedness Committees and WMAFs must aim to address the issue of both risks occurring concurrently.

Floodplain hazard mapping has been undertaken for the whole island with flood extent lines marked on the 1:2,500 maps. Severity of flooding, however, will be variable within this area: generally the higher up the watershed, the more aggressive will be the flood wave due to the steeper slope and more confined conveyance channel. Certain watersheds are confined or narrow over much of their length and can cause considerable damage when funnelled flows reach the downstream centres of population (eg Canaries, Castries, Dennery). There is an urgent need for tighter planning controls within the flood hazard areas: if building is allowed, it should be with an open lower storey.

Infrastructure affected by the flooding during TSD and 26 October 96 is in danger of being affected by future flooding situations. The infrastructure affected, and those dwellings damaged, should be addressed as part of WMAF activities. Recommendations should be made for flood proofing, flood protection measures and/or for the relocation of the structure.

c) Land Zoning

Building should be encouraged in the drier, less steep areas, nearer the coast (especially Agro-ecological Zones Em and Dm, - see Figure 1.1 of Annex 4), and discouraged in steeper, inland areas. The Land Taxation mechanism coupled with a computerised Land Bank could be used to facilitate this.

8.4 ENGINEERING & OPERATIONS

- a) No new road construction (or road repair) should be allowed in sensitive areas, ie steep or landslide prone areas, or above drinking water intakes.
- b) Materials from de-silting operations should be selectively moved to nearby shallow soil areas on adjacent upland areas, to increase capability of these lands.
- c) The function of the floodplains as a vital overspill during floodpeaks and as a trap for silt and debris should be appreciated. Riverbanks should be protected by at least a double row of trees. Straightening of river channels should be discouraged. Building on the floodplain, particularly in the lowermost parts, should be discouraged. Land zoning for these areas needs urgently to be re-assessed.

8.5 WATER RESOURCES MANAGEMENT AND MONITORING

- a) Upper watershed areas are not covered by any recent aerial photography, and this is a major constraint in land use studies and monitoring. Conventional air photography is not suitable for these conditions and Small Format Air Photography should be commissioned, which would involve photography from a helicopter hired at short notice on an hourly basis.
- b) Continuous flow gauges and sediment gauges on major rivers need to be installed. The dry season river discharge monitoring programme needs to be made more systematic and regular. The dry season discharges would be mainly gauged by current metering: these values need to be analysed in the context of upstream abstractions and the rainfall characteristics of the period prior to gauging.
- c) Dry Season water resources are very scarce and without much scope for major irrigation development: irrigation should thus be concentrated on the highest value (mainly horticultural) crops. However, the database on dry season flows is small and needs to be improved to enable a forthcoming FAO irrigation study to be well founded. Considering the scarcity of dry season water, there is need to introduce the licensing of abstractions and some means of charging for irrigation water, preferably by volume but at least by irrigated area. Legislation to enable this needs to be designed and put into effect..
- d) Improved water quality monitoring is advocated, particularly of the river waters upstream of WASA intakes, and such testing should include pesticide residues. Sampling of lower positions in the river systems, particularly during the dry seasons also needs to be undertaken.

9 COMMUNITY INVOLVEMENT AND IMPLEMENTATION

Perhaps the most far reaching proposal embodied in the plan, is the role of the community. The Consultants have put the onus for watershed management firmly on the rural communities, and through a bottom up approach, see this as the most probable means of achieving the necessary

improvements. In view of Government's poor record in environmental matters; under investment in river and drainage systems, lack of political will to implement environmental legislation and lax control over new building or other potentially risky developments, the Consultants reason that, given the right framework and support, the stakeholders themselves, with their intimate knowledge of their environment and its problem areas, would do a better job.

The trial at Dennery has yielded very encouraging results, but the newly formed WMAF will need careful nurturing until it matures.

The Consultants propose the development of 20 Watershed Management Action Force (WMAF), one for each major watershed and with smaller less important watersheds sharing a WMAF.

Institutionally it is proposed that the Land Conservation Board, currently moribund, be reformed and given an executive arm; a restructured AESD. Within this overall framework, a number of Community Participation Coordinators and a series of Technical Operations Teams, would support and guide WMAFs and participate in their formation. As they gather strength, the WMAF should become increasingly responsible for the implementation of minor works, while major works, identified in their prioritised annual plans, would form the basis of MCWT&PU annual programmes. Work carried out, regardless of funding source would be closely monitored by the WMAF. Although initially supported by government, through annual estimates, it should prove possible over time for WMAFs to generate at least a proportion of their own revenue.

10 THE PROPOSED PROGRAMME

The Consultants made every attempt to sound out the Government's attitude towards the type and pace of a development programme required. A meeting of government "stakeholders" proved very useful and a presentation to the National Steering Committee did not reveal any serious disagreements with the proposals tabled.

To establish the order of development, a prioritisation exercise was undertaken, and while this was to a degree subjective it nevertheless established a rationale. A further assumption was made, that some of the smaller and less important watersheds would share a WMAF, and this together with geographical proximity modified the priority order, and reduced the number of WMAFs to 20 for the 37 watersheds on the island.

Recurrent costs and capital costs were then calculated, based on an "average" rainfall year. (Costs were estimated for "dry", "average" and "wet" years).

Implementation of the development plan is critically dependent on GoSL taking the following actions which aid donors might require as pre-conditions for loan or grant assistance:

- appoint members to the National Environmental Commission and ensure that the NEC meets at least every second month;
- appoint members to the Land Conservation Board and ensure that the Board meets on alternate months to the NEC;
- consider appointing representatives of SLBGA, the tourist industry and a banana grower as non-government members of the Board;
- close down the Agricultural Engineering Services Division of the Department of Agriculture and transfer all staff and assets to the LCB;
- ensure that recurrent budgets as set out in the development plan are made available to the LCB;

- consider the transfer of staff from the MCWT&PU and possibly the Extension Division of the Department of Agriculture to fill vacant posts in LCB
- MAFF&E and preferably other Ministries should match the boundaries of the eight administrative regions to the 37 watersheds in the Island;
- open discussions with one or more aid donors regarding the provision of an initial tranche of loan funds estimated at EC\$ 7 million over 5 years;
- discuss with one or more aid donors the provision of grant aid totalling EC\$ 2.2 million, plus 87 staff months of foreign consultancy and local/overseas training over the 5 year period.

Chapters 8 and 9 specify the costs involved in mounting the development programme and recognise that the LCB's income over the plan period will be negligible. Whilst everyone recognises the environmental problem, particularly after torrential or even heavy rain, it is, at present, difficult to place a value on the "dis-benefits", the damage caused by not carrying out the programme.

11 GRANT AID FOR THE LAND CONSERVATION BOARD

The development plan is based on the assumption that significant external assistance will be forthcoming.

Such assistance will cover:

- LCB Adviser;
- Legal Specialist;
- Review Mission after Year 2;
- Capital for improvement to the LCB offices, vehicles and equipment;
- A soil conservation/trash management programme for execution through the SLGBA;
- A crop diversification consultancy;
- River system low flow studies;
- Systematic landuse mapping using small format aerial photography;
- Trash management/run-off trials.

Chapter 1

1 INTRODUCTION

1.1 TROPICAL STORM DEBBIE

Tropical Storm Debbie (TSD) hit St. Lucia on the 9/10th September 1994, causing severe damage to the environment, property, agricultural land and the river/drainage system. Some loss of life was also recorded and many people were made homeless. Losses were estimated at EC\$ 112 million.

An urgent request for assistance from the Government of St. Lucia (GoSL) to the World Bank brought a quick response and a team visited the island in late October and preparations were made to field a team of consultants. This team, with support from the British Development Division in the Caribbean (BDDC) worked in St. Lucia from 29th November to 23rd December 1994.

The resulting report, "Watershed and Environmental Management Project" dated December 1994, proposed a two phase strategy:

- Phase 1 comprise a priority works programme to effect repairs to the rivers and drainage systems. This was costed and a loan of EC\$14.3 million was agreed with the World Bank. The British Overseas Development Administration (ODA) agreed to fund the technical assistance component and a Supervising Engineer arrived in February 1995. The Phase 1 works were largely completed by May 1996.
- Phase 2 was designed to take a longer term view of environmental management in order to achieve sustainable development of land and water resources through watershed management.

1.2 PHASE 2

Phase 2 is funded by BDDC who produced their own Project Document in consultation with GoSL and based on the World Bank proposal. The contract was awarded to Hunting Technical Service Ltd. in association with Mott MacDonald Ltd. The Phase 2 study was completed by the end of November 1997, and project outputs are:

- detailed Watershed and Environment Management Plans for two selected watersheds; Dennery and Cul de Sac
- a blueprint for an island wide plan including an implementation timetable

The full Project Memorandum which included Terms of Reference for all inputs is reproduced in Annex 12 to this report.

Phase 2 encompasses a wide range of issues calling for inputs from several disciplines which were:

- river engineering and hydrometeorology
- land use
- socio economy
- geotechnology
- environment
- institutions and legalisation
- landslide hazard mapping

By combining disciplines, the ToR were accommodated by a core team of five, which provide some additional agricultural expertise plus short term inputs from specialists. One significant departure from the planned inputs, was the abandonment of a Sociology input of 1.5 months, in favour of

employing, on a short term contract, a Community Participation Coordinator, which enhanced the project's potential for involving stakeholders. An important Community Participation trial resulted.

The project approach centered around four main themes:

- a) identification of problems experienced and solutions applied and their relative degrees of success.
- b) identification and field testing of solutions to unsolved problems (e.g. flood hazard planning, landslide/slope stabilisation, sustainable land use, river stabilisation, social impact, conservation of biodiversity and environment), disaster preparedness and management.
- c) review of existing institutional infrastructure and legislation for integrated watershed management; participatory design of an improved institutional structure, identifying necessary human resource development; recommendation of legislative reform to enhance effectiveness and efficiency, including powers and means of enforcement.
- d) on the basis of the above, design and implementation of pilot watershed management plans for two selected sites; design of a strategy for extrapolating pilot site results to the whole island system on a watershed basis.

1.3 COMMENTS ON THE CONSULTANCY

From the start, the project was seen as requiring a three stage approach:

- an initial series of inputs;
- a six month gap;
- a final series of inputs.

The initial inputs were made between October 1996 and March 1997 – the gap was from March to September 1997 and the final inputs from September to November 1997.

During the initial inputs items a) and b) were completed and part of item c). Two pilot, watersheds were selected at an early stage in close collaboration with government: they were Dennery on the east coast and Cul de Sac on the west. Some studies were focused specifically on these areas, while concurrently, other fundamental issues were examined on a national basis. During this period, a programme of field trials was devised, which comprised agricultural, community participation, river engineering, bioengineering and geotechnical/landslide trials. During the six month absence of the Consultants, the trials were constructed with varying degrees of success with the intention of evaluating outputs during the second series of inputs and applying lessons learned to the watershed plans. The second series of inputs was mainly focused on the production of the draft final report and watershed management plans for the two pilot watersheds and development of an outline development plan for the remaining watersheds of the island.

The project structure has met with some criticism in that:

- it did not allow for continuity;
- a six month period for trial construction was insufficient for any detailed evaluation particularly for the longer term trials.

However, some continuity was maintained over the 6-month 'gap period' by the Land Use and Environmental Specialist having to complete his initial input in June/July, and the Socio-Economist in July/August, leaving only the months of April and May with no expatriate inputs.

Apart from the project structure, the time allowed for the project was inadequate. The ToR were extremely demanding, with some aspects reliant upon other people making a timely input. Where this involved government, procedures are slow and caused frustrating delays. Towards the end of the project period, the Consultants were forced to request a six day extension for two team members, in order to complete the Draft Final Report.

The relationship with government personnel was excellent throughout and the Consultants enjoyed good cooperation at all levels. When important issues of principle were at stake, meetings at P.S. level have reassured the Consultants of Government's long term commitment to the Watershed Management Project's objectives.

When the Consultants returned in September 1997, several changes had taken place: The General Election in May saw a change of government. Subsequent re-shuffles have been made which included:

- a new Permanent Secretary and P.A.S. at the Ministry of Agriculture;
- a new Permanent Secretary and P.A.S. at the Ministry of Works.

Other significant changes, as a result of study leave were:

- Project Co-ordinator – Martin Satney was replaced by Felix Jaria at AESD
- Co-ordinator, Ministry of Planning – Ms. Rufina Charlery was replaced by Mr Michael Gittens.

The Project therefore faced having to establish new lines of communication, plus ensuring that senior staff, whose decisions affected the Project at a more fundamental level, were well briefed. In particular the former Project Co-ordinator did all in his power to ensure a smooth handover and minimal disruption to the projects' progress.

A major problem of the project was lack of up-to-date aerial photography on which land use mapping and assessments could be based. The 1992 air photography covered only the coastal 50% of Cul de Sac, and almost nothing of Dennery. The Consultants thus proposed undertaking their own 'Small Format Air Photography' (SFAP) from a helicopter, but bad weather prevented this form being undertaken until very late in the assignment. Elevation of coverage (2,500 ft., instead of the intended 4,500 ft.) meant that four times as many photos as originally intended had to be taken. Although quality of interpretation and mapping was very good, (see Chapter 6) there was insufficient time to undertake routine mapping over the whole of the pilot area. However, the usefulness and cost-effectiveness of the technique was confirmed, and it is suggested that this be used over the entire Island in due course.

1.4 REPORTING

Reporting was a little different from that stated in the Project Document:

- | | |
|---|--------------|
| • Inception Report | October 96 |
| • Draft Technical Reports | December 96 |
| • Progress Report | January 97 |
| • Interim Report | March 97 |
| • Progress Report | September 97 |
| • Draft Final Report and Watershed Plans supported by Technical Annexes | November 97 |
| • Final Report | August 98 |

Included in the River Engineers' and the Environmentalists ToR was a commitment to review Phase 1 works. This was completed during the first series of inputs and is published in Annexes 1 and 8. As this work, apart from the lessons learned, does not affect the development of watershed plans, it is not referred to elsewhere.

This report is set out as follows:

- Main Report in nine Chapters covering
 - 1 Introduction
 - 2 Physical and Economic Characteristics of the Island
 - 3 Background to Watershed & Environmental Management in St. Lucia
 - 4 Assessment of the Environmental Issues
 - 5 Agriculture and Crop Diversification
 - 6 Pilot Watershed and Environmental Management Planning
 - 7 Planning Replication Process for the Island
 - 8 National Watershed and Environmental Management Plan
 - 9 Grant Aid Recommendations

- Technical Annexes – containing background material
 - Annex 1 Review of Phase 1
 - Annex 2 Hydrology and Meteorology
 - Annex 3 Floods and Flood Plain Hazard Mapping
 - Annex 4 Agro-Ecological Zoning, Soils, Landuse and Agriculture
 - Annex 5 Possibilities for Alternative Cropping
 - Annex 6 Landslide Hazard Mapping
 - Annex 7 Field Trials and Evaluation
 - Annex 8 Environmental Assessment and Management
 - Annex 9 Main Socio Economic Issues
 - Annex 10 The Community Participation Programme
 - Annex 11 Legislation and Institutions
 - Annex 12 Project Memorandum and Terms of Reference

1.5 OBJECTIVE AND ISSUES

The development of watershed and environmental action plans is to address the inappropriate land use practices on the Island which are causing the Environmental Degradation of the River Basins and Coastal Marine Areas.

This environmental degradation is attributable to a number of causes including:

- Increase in the coverage of agriculture, which is reducing the Area of Tropical Rain forests and particularly the Area of Natural Vegetation Cover on Steeply Sloping Lands;
- Increasing the demands on land for new Housing and Infrastructure;
- Increasing the rate of Soil Loss from the Island, particularly newly cultivated areas;
- Increasing the unsightly and often unhealthy accumulation of solid waste on land;
- Increasing the volume of solid waste which is entering the marine environment;
- Increasing the use and possible misuse of agro-chemicals;
- Increasing the use of non bio-degradable materials;
- Increasing the risk of natural calamities either during flood/storm events or during droughts.

and is resulting in:

- Reducing the Availability of Surface Water for Drinking Water Supplies;
- Reducing the Quality of Surface Waters for Potable Use;
- Reducing the extent and viability of coral reefs and other marine ecosystems;
- Reducing the habitat area for endangered species and indigenous wildlife;
- Reducing the attractiveness of the Island to both nationals and tourists alike;
- Reducing the security of infrastructure due to more aggressive natural calamities.

and will:

- Reduce the ability for the Island to be meet future water supply demands;
- Reduce the potential for the Island to meet its own food needs;
- Reduce the attractiveness of the Island for future tourism hence revenue potential;
- Reduce the ability of the coral reefs to recover;
- Reduce the quality of life on the Island for future generations.

The problems are mainly being caused by:

- Lack of effective Watershed and Environmental Management;
- Lack of Adherence to Legislation, Development Guidelines and Control;
- Lack of Action in addressing the Issue of Cultivation of Banana & Annual Crops on excessively steep slopes;
- Lack of Awareness and Community Level Campaigns to address the problems;
- Delays in the Institutional Responses in addressing the various Issues.

Central to the issues related to encroachment, soil conservation and crop diversification are the problems associated with land tenure on the Island and general socio-economic conditions.

- Reducing the Availability of Surface Water for Drinking Water Supplies
- Reducing the Quality of Surface Water for Potable Use
- Reducing the extent and visibility of coral reefs and other marine ecosystems
- Reducing the impact on endangered species and indigenous wildlife
- Reducing the attractiveness of the island to both tourists and tourists alike
- Reducing the capacity of infrastructure due to more aggressive natural resources

- Reducing the ability for the island to meet future water supply demands
- Reducing the potential for the island to meet its own food needs
- Reducing the attractiveness of the island for future tourism based revenue potential
- Reducing the ability of the coral reefs to recover
- Reducing the quality of life on the island for future generations

The problems we identify being caused by:

- Lack of effective Watershed and Environmental Management
- Lack of attention to Legislative Development Initiatives and Control
- Lack of action in addressing the loss of Ecosystem of Forests & Animal Groups on
- Lack of Awareness and Commitment to Environmental Protection
- Lack of the Institutional Experience in addressing the various issues

There is the need to conduct a comprehensive and detailed assessment and to provide a detailed report on the island and general socio-economic conditions.

Chapter 2

2 MAIN PHYSICAL AND SOCIO-ECONOMIC CHARACTERISTICS OF THE ISLAND

2.1 AGRO CLIMATE

2.1.1 Introduction

Agro-ecological zoning is the essential precursor for scientific land evaluation. In the following sections an agro-ecological zoning map is derived, based on an analysis of climatic parameters, lithology, soils, topography and resultant ecological / vegetation zones which can be mapped at a general scale of 1:100,000. These zones can then be related to crop suitability at a general level. However, within each of the zones local factors such as slope and soil depth may play a dominant role and these factors would determine the precise suitability rating for any given crop. These factors are only mappable at a more detailed scale, say 1:10,000 or 1:12,500.

2.1.2 Rainfall

Mean annual rainfall varies from 1450mm at Hewanorra to some 3450mm at Edmund Forest, average monthly and annual figures being shown in Table 2.1. In general, rainfall is closely related to elevation, with the areas at sea-level in the extreme North and South of the island receiving the least rainfall (mostly cyclonic, with some convectional rainfall). Adjacent sea areas in the Eastern Caribbean receive a mean annual rainfall of some 900mm, this being cyclonic. The high interior of the island receives the most rainfall, with a high proportion of this being orographic. With the central water-divide being closer to the W than the E coasts, and this distance being only 8-9km, rainfall on the West coast tends to be higher than that on the East coast. (For larger islands – e.g. Martinique - with a higher water divide and longer leeward slope, a very marked rain shadow effect is seen, but this does not apply to St Lucia and the smaller islands).

For all stations, rainfall is consistently higher for the latter 6 months of the year, with maximum rainfalls being experienced in September to November. Mean monthly maxima vary from 190mm to 430 mm between the different stations. Conversely February to May are the driest months, with mean monthly minima varying between 45mm and 170mm.

The distribution of annual rainfall over the island is given in Figure 2.1. The isohyets represent the average annual totals at 23 principal rainfall stations for the period 1985 to 1995 inclusive. This period has the best checked and reliable records. Dry season isohyets are presented in Figure 2.2.

2.1.3 Potential Evapotranspiration

Potential evapo-transpiration (ET_o) has been calculated by AESD from measurements on temperature, sunshine, windspeed, and relative humidity, and application of the Penman formula. ET_o refers to the evapo-transpiration which would result from a short grass vegetation, with soil well supplied with water (i.e. near field capacity). Measurements on actual (Class A) evaporation have been made for five stations, and comparison can be made with Penman (ET_o) values: generally Class A pan evaporation figures are some 15-30% above the ET_o calculations.

Total annual potential evapotranspiration (ET_o) values vary from 1310mm in the central mountains to over 1960mm at Hewanorra. Monthly maximum ET_o values are seen during the latter part of the drier season (May), with values varying from 133 to 201mm/month. Monthly minimum values are seen in January, with a range of 83 to 146mm respectively.

TABLE 2.1: MEAN MONTHLY RAINFALL TO 1995 (mm)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERIOD	Years
La Caye	91	59	86	80	119	121	158	198	230	239	253	118	1752	75 - 95	21
Cardi	128	86	118	95	177	118	169	254	310	241	297	112	2105	86 - 95	10
Errand	137	85	122	87	180	148	184	243	368	295	327	136	2312	87 - 95	9
Mamiku	96	54	87	86	93	110	131	192	263	223	225	108	1669	85 - 95	11
Patience	107	72	77	88	116	136	172	221	251	271	283	140	1933	75 - 95	21
Troumasse'	74	48	73	52	83	105	148	168	231	192	230	77	1482	83 - 95	13
Mahaut	169	110	150	101	155	180	237	263	357	317	329	170	2537	84 - 95	12
Edmund Forest	229	188	190	173	223	273	337	347	431	406	424	220	3439	79 - 95	17
Hewanorra	86	53	69	52	82	96	164	155	239	176	196	86	1452	82 - 95	14
Beausejour	87	47	60	61	85	110	167	177	207	194	188	103	1485	75 - 95	21
Saltibus	177	116	149	108	130	201	248	281	391	312	390	170	2673	85 - 95	11
Delcer	95	53	63	47	84	140	172	168	246	210	228	84	1591	83 - 95	13
Union Vale	110	65	80	64	81	165	183	240	314	240	257	104	1903	85 - 95	11
Barthe Nursery	159	123	116	101	136	203	262	299	317	321	337	174	2547	75 - 95	21
Winban	131	75	94	79	102	154	227	266	295	241	270	147	2080	75 - 95	21
Soucis	136	73	88	88	115	163	215	288	299	282	268	148	2164	75 - 95	21
Bexon	164	115	151	89	130	187	235	325	426	286	362	162	2630	86 - 95	10
Barre de L'isle	145	102	133	117	180	158	233	284	310	325	347	169	2504	75 - 95	21
Gov't. House	104	72	86	85	132	165	224	263	283	231	240	108	1992	75 - 95	21
George V Park	117	69	86	76	122	145	179	249	296	237	280	118	1973	85 - 95	11
Vigie	110	68	73	68	109	141	188	251	257	243	234	134	1876	75 - 95	21
Union Agr. St.	125	82	92	91	123	150	200	259	269	266	285	138	2080	75 - 95	21
Trouya	91	58	65	76	113	136	180	208	225	206	240	101	1698	75 - 95	21
Cap Estate	63	46	50	52	97	95	121	168	179	182	191	89	1333	75 - 95	21
MEAN,ALL STNS	122	80	98	84	124	150	197	240	291	256	278	130	2050		

TABLE 2.2: MEAN MONTHLY DEFICIT / SURPLUS OF RAINFALL minus POTENTIAL EVAPOTRANSPIRATION (mm)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX. ACCUM. DEFICIT
La Caye	-28	-68	-62	-77	-48	-31	-5	54	102	115	144	11	-319
Cardi	12	-35	-24	-56	14	-33	12	114	185	114	183	8	-135
Errand	22	-28	-10	-53	28	7	38	113	253	177	221	40	-91
Mamiku	-23	-73	-60	-71	-74	-42	-31	47	135	100	116	1	-374
Patience	-12	-55	-71	-69	-51	-17	10	76	123	147	174	33	-275
Troumasse'	-65	-94	-95	-126	-108	-102	59	18	109	54	97	-34	-624
Mahaut	86	13	28	-18	11	61	109	150	237	215	241	92	-18
Edmund Forest	146	91	68	54	79	154	209	234	312	304	336	142	
Hewanorra	-59	-97	-108	-135	-119	-123	-33	-3	110	31	56	-31	-707
Beausejour	-47	-91	-102	-111	-100	-91	-14	32	89	60	60	-5	-562
Saltibus	94	19	27	-11	-14	82	121	168	272	210	302	92	-25
Delcer	-30	-76	-89	-114	-88	-48	3	33	136	85	108	-16	-461
Union Vale	9	-54	-70	-82	-95	18	27	101	167	115	149	8	-301
Barthe Nursery	76	26	-6	-18	-8	84	134	186	198	219	249	96	-32
Winban	13	-49	-50	-79	-71	5	63	122	168	119	163	42	-250
Soucis	18	-51	-56	-70	-58	14	51	145	172	160	161	43	-234
Bexon	88	26	39	-20	-3	77	118	221	316	193	281	90	-23
Barre de L'isle	62	5	11	-2	36	39	105	171	191	223	259	91	-2
Gov't. House	-7	-48	-53	-63	-25	22	71	127	163	115	138	7	-196
George V Park	6	-51	-53	-71	-35	1	26	113	176	121	177	18	-210
Vigie	-9	-59	-75	-89	-58	-12	25	107	129	119	125	27	-301
Union Agr. St.	6	-45	-56	-66	-44	-2	38	114	141	143	176	31	-213
Trouya	-41	-80	-98	-97	-71	-50	1	57	96	71	115	-11	-448
Cap Estate	-82	-104	-126	-136	-104	-123	-76	11	50	37	51	-27	-779

Source: Analysis by HTS based on primary data from AESD, Ministry of Agriculture.

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Figure 2.1

Annual Rainfall Isohyets

Average Annual Rainfalls for the Period 1985-95 inclusive (stations shown)

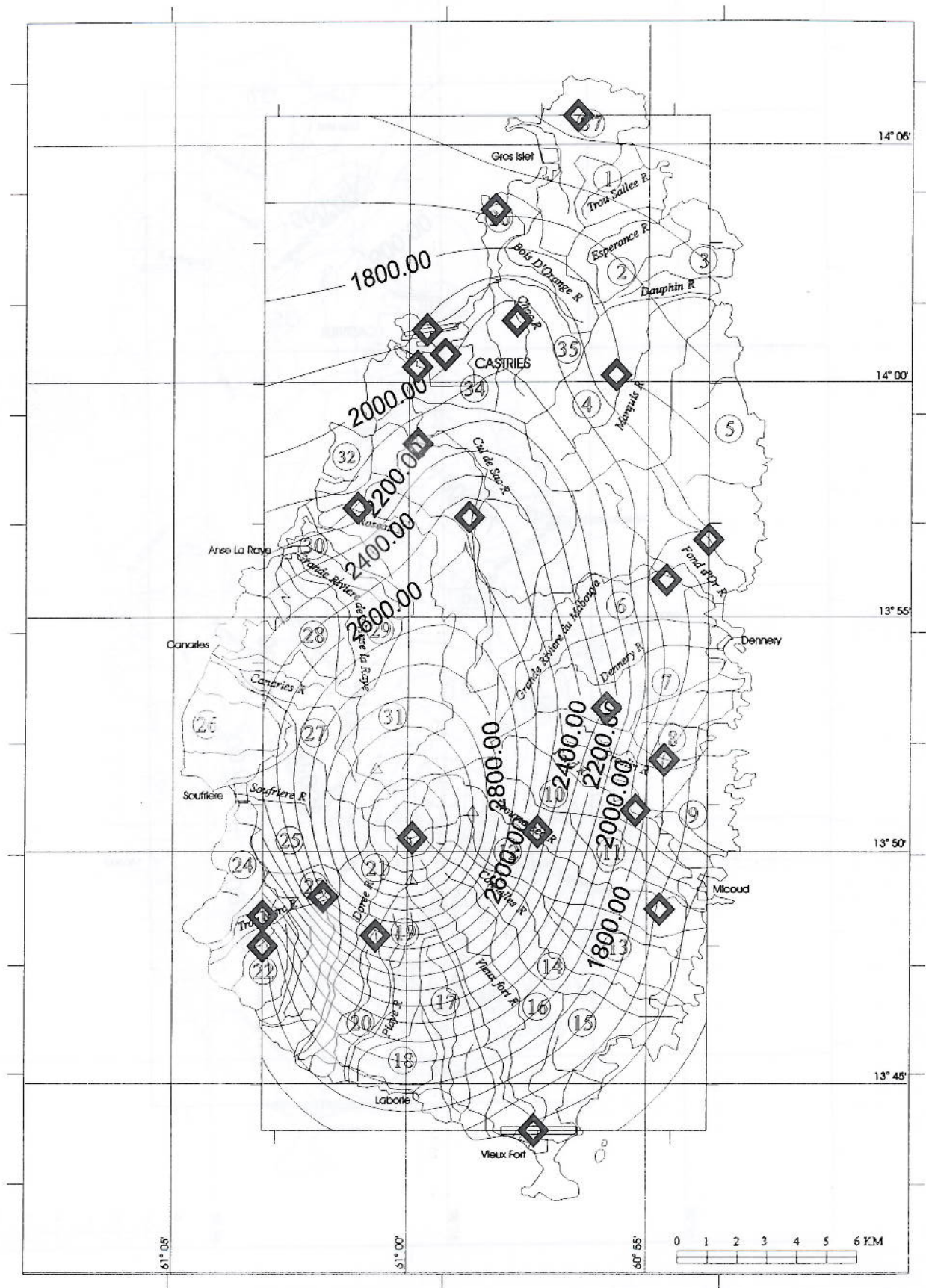


Figure 2.2

Dry Season Rainfall Isohyets

Based on average 6 month rainfalls for Dec-May (inclusive) 1985-95 (inclusive), 24 stations

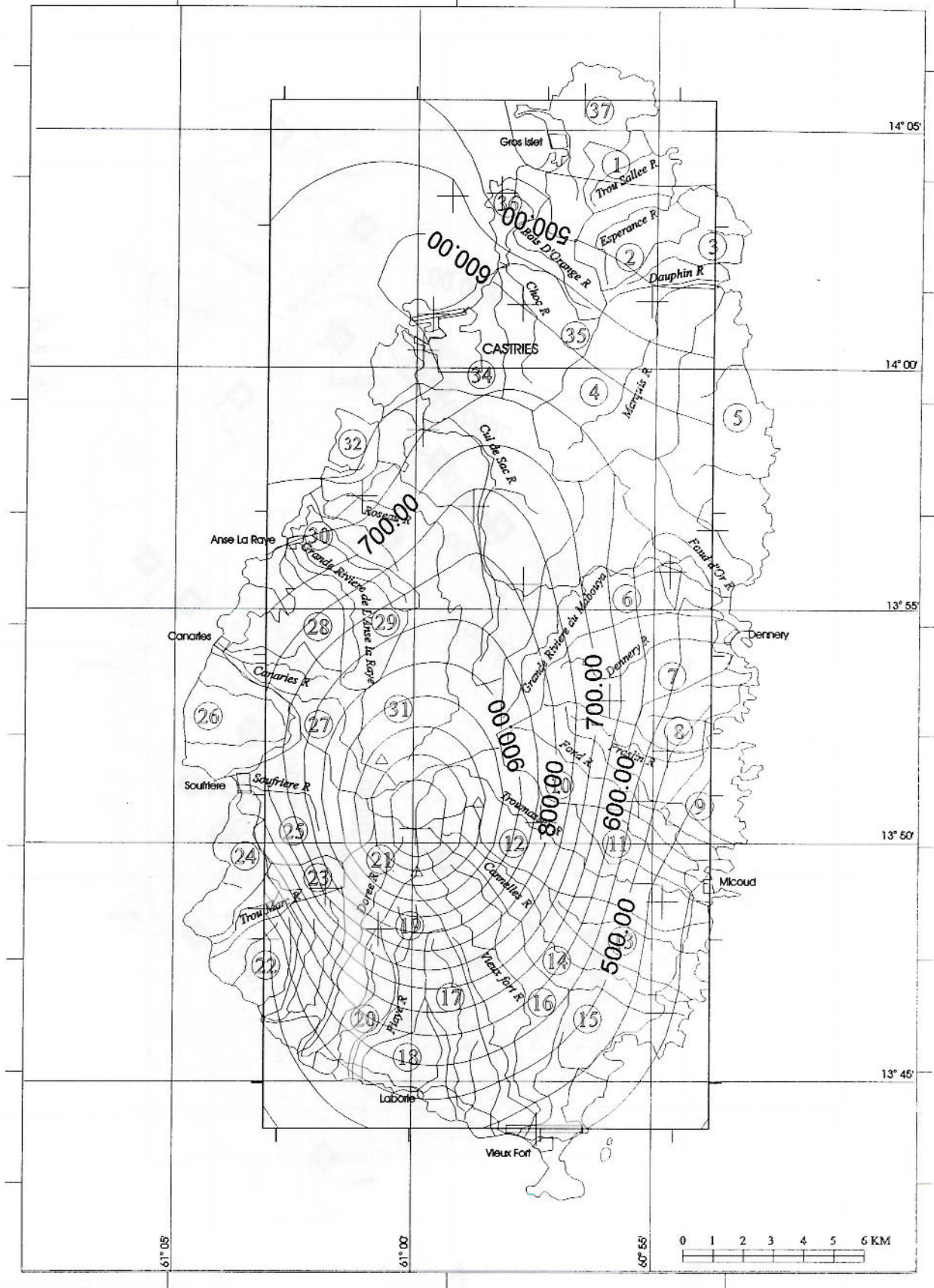


FIGURE 2.3: ST LUCIA: AGRO-ECOLOGICAL ZONING MAP LEGEND

UNIT	Rainfall Range ____ (mm) ____ (ins)		Annul. Accum Soil Moisture		Months with Rainfall		Severity of Dry Season	Clay Mineralogy	Modal Elevation Range (feet)	Percentage of Unit Within Slope Classes					Area (approx) '000ha %					Percentage of Island Within Slope Classes																	
	<0.5 ETo	0.5- ETo	1.0- ETo	>2.0 ETo	0	0				4	8	None	0-2	2-5	5-10	10-20	>30	0	2	5	10	20	30	0	0.0	0.0	0.0	0.0	0.0								
Ah	>3000	>120	0	0	0	0	4	8	None	Allophane	1000 - 3000	0	0	5	15	35	45	4.3	7.0	0.0	0.0	0.0	0.4	1.1	2.5	3.2	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.7			
Ar										Rock & Debris	1000 - 3000	0	0	0	0	5	30	65	0.6	1.0	0.0	0.0	0.0	0.0	0.1	0.3	0.7	0.0	0.0	0.0	0.0	0.1	0.3	0.7			
Bh										Aliph-Kaol-Hall	700 - 1800	0	5	5	15	45	30	5.9	9.6	0.0	0.5	0.5	1.4	4.3	2.9												
Bk	2500 -3000	100 -120	0	0	2	4	6	6	V.Weak	Kaol-Halloysite	300 - 900	0	5	5	15	35	40	3.4	5.5	0.0	0.3	0.3	0.8	1.9	2.2												
Br										Rock & Debris	400 - 1800	0	0	0	10	30	60	0.7	1.1	0.0	0.0	0.0	0.1	0.3	0.7												
Ba										Alluvium(mixed)	35 - 150	65	30	5	0	0	0	0.6	1.0	0.7	0.3	0.1	0.0	0.0	0.0												
Ch										Halloysite(hydrd)	500 - 1000	5	5	10	20	40	20	2.6	4.2	0.2	0.2	0.4	0.8	1.7	0.8												
Ck	2000 -2500	80 -100	0-200	0	4	4	4	4	Weak	Kaol-Halloysite	200 - 600	5	5	5	15	45	25	10.8	17.5	0.9	0.9	0.9	2.6	7.9	4.4												
Cm										Mont-Kaol(shlw)	200 - 400	5	5	5	15	25	40	1.7	2.8	0.1	0.1	0.4	0.7	1.1	0.3												
Cr										Rock & Debris	100 - 500	0	0	0	10	30	60	0.4	0.6	0.0	0.0	0.0	0.1	0.2	0.4												
Ca										Alluvium(mixed)	15 - 50	70	30	0	0	0	0	1.2	1.9	1.3	0.6	0.0	0.0	0.0	0.0												
Dk										Kaol-Halloysite	50 - 400	5	2	15	30	38	10	5.5	8.9	0.4	0.2	1.3	2.7	3.4	0.9												
Dm	1750 -2000	70 - 80	200-400	2	4	4	4	2	Moderate	Mont-Kaol(shlw)	50 - 400	5	5	5	15	25	40	7.9	12.9	0.6	0.6	1.9	3.2	5.2	1.3												
Dr										Rock & Debris	50 - 400	0	0	0	10	30	60	0.2	0.4	0.0	0.0	0.0	0.0	0.1	0.2												
Da										Alluvium(mixed)	3 - 40	85	15	0	0	0	0	1.6	2.6	2.2	0.4	0.0	0.0	0.0	0.0												
Em	1500 -1750	60 - 70	400-600	4	4	4	4	0	Severe	Mont-Kaol(shlw)	20 - 300	5	5	5	15	40	30	7.9	12.9	0.6	0.6	1.9	5.2	3.9	0.6												
Ek										Kaol-Halloysite	20 - 300	5	5	5	15	40	35	2.0	3.2	0.2	0.2	0.5	1.3	1.1	0.0												
Er										Rock & Debris	20 - 300	0	0	0	5	30	65	0.2	0.3	0.0	0.0	0.0	0.0	0.1	0.2												
Ea										Alluvium(mixed)	3 - 40	85	15	0	0	0	0	1.0	1.6	1.4	0.2	0.0	0.0	0.0	0.0												
Fm	<1500	<60	>600	6	2	4	0	0	V.Severe	Montm(shallow)	10 - 200	5	5	5	30	35	20	2.7	4.4	0.2	0.2	1.3	1.5	0.9	0.2												
Fa										Alluvium(mixed)	3 - 20	85	15	0	0	0	0	0.2	0.4	0.3	0.1	0.0	0.0	0.0	0.0												
																				9	5	10	22	35	19												

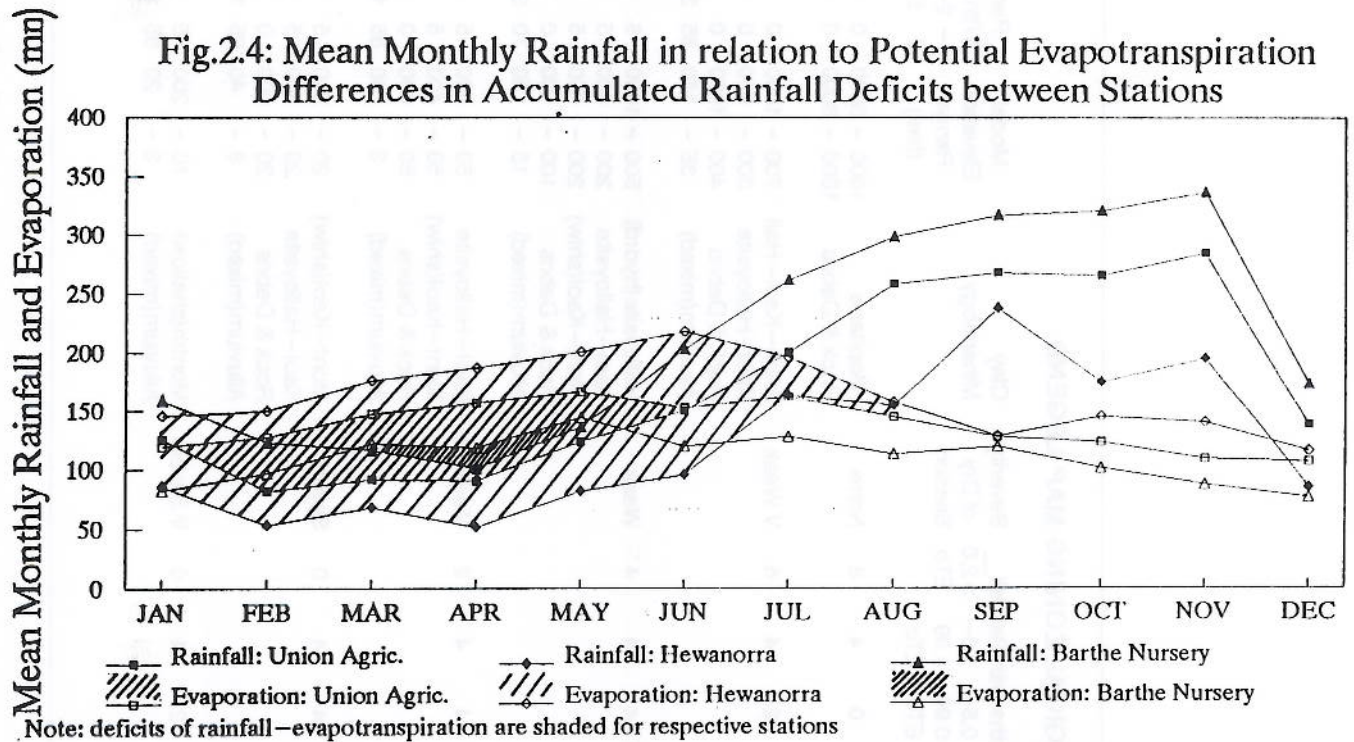
2.1.4 Deficits or Surpluses of Rainfall minus Potential Evapo-transpiration

Monthly deficits or surpluses of rainfall minus evapo-transpiration are shown in Table 2.2 for the above stations. Mean monthly accumulated deficits over consecutive months are summed and are shown in the last column in that table.

Results show that accumulated deficits vary from zero (central mountainous part of island) to more than 700 mm (coastal regions in extreme north and south). Accumulated deficits represent perhaps the most important parameter for agro-climatic zonation, and thus iso-lines at 0, 200, 400, 600 and 700 mm deficits are plotted on the island map separating Zones A and B, C, D, E and F respectively (see Figure 2.3).

Figure 2.4 plots these accumulated deficits for three stations:

- Hewanorra, representative of the driest part of the island (Zone F),
- Barthe Nursery, one of the wetter stations (Zone B), and
- Union Agricultural Station, representative of the intermediate zone (between Zones C and D).



The mean deficit for Hewanorra is far in excess of the available water holding capacity (AWC) of even a very high-AWC soil, and thus the soil profile would be at wilting point for several months in an average dry season. The surplus of rainfall over evapo-transpiration in the wet season also will only just return the profile to field capacity before the next dry season begins. Net leaching of plant nutrients will thus be relatively small, for an average year. With irrigation, this land would show high capability

Table 2.3: Analysis of Wet and Dry Months Based on Monthly Averages Over 10-20 Year Period ratings for many crops. However, for rainfed cropping the land would be Not Suitable for most perennial crops, but probably suitable for short-season seasonal crops.

TABLE 2.3: ANALYSIS OF WET AND DRY MONTHS BASED ON MONTHLY AVERAGES OVER 10-20 YEAR PERIOD

STATION:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	No. of Months in Classes:			Agro - Climate Zone		
													DD	d	w			
Edmund Forest	WW	w	w	w	w	WW	WW	WW	WW	WW	WW	WW	WW	0	0	4	8	A
Bexon	WW	w	w	d	d	w	WW	WW	WW	WW	WW	WW	WW	0	2	3	7	B
Mahaut	WW	w	w	d	w	w	w	WW	WW	WW	WW	WW	WW	0	1	5	6	B
Saltibus	WW	w	w	d	d	w	w	WW	WW	WW	WW	WW	WW	0	2	4	6	B
Barthe Nursery	w	w	d	d	d	w	WW	WW	WW	WW	WW	WW	WW	0	3	3	6	B
Barre de L'isle	w	w	w	d	w	w	w	WW	WW	WW	WW	WW	WW	0	1	6	5	B
Soucis	w	d	d	d	d	w	w	WW	WW	WW	WW	w	w	0	4	4	4	C
Errand	w	d	d	d	w	w	w	WW	WW	WW	WW	w	w	0	3	6	3	C
George V Park	w	d	d	d	d	w	w	WW	WW	WW	WW	w	w	0	4	5	3	C
Cardi	w	d	d	d	w	d	w	WW	WW	w	WW	w	w	0	4	6	2	C
Gov't. House	d	d	d	d	d	w	w	w	WW	w	WW	w	w	0	5	5	2	C-D
Union Agr. St.	w	d	d	d	d	d	w	w	WW	WW	WW	w	w	0	5	4	3	C-D
Union Vale	w	d	d	DD	DD	w	w	w	WW	w	WW	w	w	2	2	6	2	D
Winban	w	d	d	DD	d	w	w	w	WW	w	WW	w	w	1	3	6	2	D
Patience	d	d	d	d	d	d	w	w	w	WW	WW	w	w	0	6	4	2	D
Vigle	d	d	DD	DD	d	d	w	w	WW	w	WW	w	w	2	4	4	2	D
Mamiku	d	DD	d	d	d	d	w	w	WW	w	WW	w	w	2	4	4	2	D
La Caye	d	DD	d	d	d	d	w	w	WW	w	WW	w	w	1	6	3	2	D
Delcer	d	DD	DD	DD	d	d	w	w	w	w	WW	w	w	1	6	4	1	D
Troumasse'	d	DD	DD	DD	DD	d	w	w	WW	w	w	d	d	4	3	4	1	E
Trouya	d	DD	DD	DD	DD	d	w	w	w	w	w	d	d	4	3	5	0	E
Beausejour	d	DD	DD	DD	d	d	w	w	w	w	w	d	d	3	4	5	0	E
Cap Estate	DD	DD	DD	DD	DD	DD	d	w	w	w	w	d	d	4	4	4	0	E
Hewanorra	d	DD	DD	DD	DD	DD	d	w	w	w	w	d	d	6	2	4	0	F
														5	4	3	0	F

KEY:

- Rainfall > 2* ETo
- Rainfall > ETo
- Rainfall > 0.5* ETo
- Rainfall < 0.5* ETo

- Rainfall < 2* ETo
- Rainfall < ETo

- Very Wet
- Wet
- Dry
- Very Dry

- WW
- w
- d
- DD

Source: Analysis by Hunting Technical Services, Nov. 1996, based on primary data from AESD, Ministry of Agriculture.

The mean deficit for Barthe Nursery, by contrast, is very mild, and there would be no retardation of crop or forest growth in an average season. However, the vast surplus of rainfall over evapo-transpiration in the wet season would lead to massive leaching of plant nutrients, to surface wash and mass movements, and to problems associated with excessive humidity and low sunshine. The suitability rating for many crops is thus low for this zone.

The mean deficit for Union Agricultural Station is intermediate between the above two stations, with a large soil moisture deficit developing in most seasons (c200mm), and drying out both A and B-horizons in an average soil profile. Crop growth would be retarded significantly during 1-2 months in an average year. During the wet season the soil would be brought to field capacity within the first half of the season, and net leaching would result in the second half. Analysis of data for this station is covered in greater detail in Section 1.2.4 to 1.2.6 of Annex 4.

An analysis of wet and dry months for the different stations was then undertaken, with months being put into four classes:

- WW: Monthly rainfall more than twice monthly evapo-transpiration;
- w: Monthly rainfall more than monthly evapo-transpiration, but less than twice monthly evapotranspiration.
- d: Monthly rainfall less than monthly evapotranspiration, but more than half monthly evapotranspiration.
- DD: Monthly rainfall less than half monthly evapotranspiration;

Table 2.3 presents this analysis for the different stations, this table being indexed on length and severity of dry season. Each of the agro-climatic zones, characterised firstly on the accumulated deficit, was then re-characterised on numbers of very dry, dry, wet and very wet months, the ranges varying from 5,4,3,0 at Hewanorra to 0, 0, 4, 8 at Edmund Forest.

2.1.5 Maximum Rainfall Intensities

High intensity rainfall is a major factor contributing directly to surface wash erosion, the 'erosivity of rainfall' factor in the Universal Soil Loss Equation essentially being a parameter of rainfall intensity / duration relationships.

Maximum rainfall intensities at Union Agricultural Station reached figures of 166, 90, 80, and 43mm/hour respectively for durations of 5 mins, and 1, 2 and 6 hours. This is in excess of maximum intensities experienced in most tropical areas. Rainfall intensity is discussed in detail in Chapter 4.

2.2 SOIL CONDITIONS

2.2.1 Availability of Data

Soils in the island were studied in the early 1960s by Stark et al.

Mapping was undertaken at 1:25,000 scale, most of the mapping units being complexes of two Soil Series, commonly of highly contrasting characteristics. Some 52 Soil Series, and 9 Miscellaneous Land Types were defined. Mapping units reflected also Slope Categories (with divisions at 0-2, 2-5, 5-10, 10-20, 20-30, and >30degrees); Erosion Categories (zero erosion to Grade 5 [severe erosion]), and stoniness (6 classes). Soil Series were described and discussed. Analysis of some 45 profiles were presented, covering all significant soil series. Analysis covered pH, CEC, TEB, exchangeable cations, C, N, P2O5. Soil Units were placed within a 7-class Land Capability System (Steele et al, 1954, this system being broadly similar to the 8-class USDA system).

Subsequent studies have been on:

- soil correlation and classification (Guy Smith, 1981), following very thorough work done on pedology and soil mineralogy in similar environments in the two French Islands (Colmet-Daage, Gautheyrou J and M, Cahier ORSTOM Ser.Pedologie 1968-75),
- soil run-off in relation to rainfall (Norville, 1988-90);
- soil stability (Ahmad & Sheng, 1988) followed by application by Polius, 1989;
- short term studies by WINBAN on such topics as the value of banana trash, soil acidification.

2.2.2 Soil Characteristics

Table 2.4 summarises characteristics of the 52 soil types as described by Stark et al. To this table the consultants have added the USDA classification, the probable mineralogy class (following correlation with similar soils in the French Islands) and a re-working of the analytical data, to present data for topsoil samples of the respective units. Mineralogical groupings, shown by small letters and groupings of colours on the Agro-ecological map, are as follows:

- **Allophane** (including hydrated halloysite): 'h': (shades of green). This group occupies the highest rainfall areas, particularly in the south, including areas where recent ash additions (particularly dacitic ash) are significant. Soil Series nos 4, 5, 9, 11, 14, 26, 36, are included, and textures are silt loam, through silty clay loam to silty clay, with the characteristic greasy feel of allophane being present. However, the true physical properties of allophane are poorly represented by these soils, which appear transitional to other groups. True allophane soils show very high 15-bar water contents (100% for Dystrandeps; up to 350% for Hydrandeps); very high CECs (160me/100g); very high anion fixation capacities (total phosphate may be moderate to high, but available phosphate is extremely low); low exchangeable cation concentrations; high exchangeable aluminium concentrations, and high organic matter contents. Air-dry bulk densities are commonly very low: values of 1.0 are common even for these transitional soils. Higher phosphate fertilisation in the early stages of crop establishment are necessary in these soils, and phosphate demanding crops will probably not be successful (e.g. tomatoes, peppers), or will require additional phosphate for full yields to be obtained (e.g. breadfruit).
- **Kaolinite** (including some tabular halloysite): 'k': (shades of brown). This group occupies the older landsurfaces and materials in the higher rainfall zones, generally concentrated more in the northern half of the island. Soil Series include nos 1, 2, 3, 6, 7, 8, 13, 16, 20, 21, 22, 23, 24, 25, 48, and textures are most commonly clay, but also include some silty clays and clay loams. Many soils, particularly at lower elevations and with a more appreciable dry season, show significant clay differentiation between A and B-horizons, caused most probably by clay translocation between the two. Soils fall into three USDA Orders: Inceptisols (little clay differentiation, generally more primary minerals remaining); Alfisols (enrichment of clay in B-horizon, higher base status, generally in areas having an appreciable dry season); and Ultisols (clay enrichment, but a more acidic soil, with a much lower base status at depth).

Generally these kaolinitic soils are somewhat more erodible than the allophanic soils, with alfisols being more erodible, and ultisols less erodible than the inceptisols. Organic matter contents are generally much lower than the allophanoid soils, while CEC values are lower and base status and pH somewhat higher.

TABLE 2.4: CHARACTERISATION OF THE SOIL SERIES MAPPED AT 1:25,000 SCALE (1986)

Map No.	Soil Series	Topsoil Texture	Slope Range (deg)	Internal Drainage	Annual Rain -fall Range (mm)	Available Water Holding Capacity	USDA Order	Area (Acres)	Stability	Parent Material	Mineralogy	Analysis of Topsoil (0-20cm)										
												pH	CEC	TE	Ca	Mg	K	Na	BS	C	N	P2O5
42	Annus	C	5 25 Slow		1524	3048	Vertisol	3300	F	Andes.Aglm	Montm	5.6	55	48	27	20	0.2	2.1	85	2.0	0.2	30
17	Anse	C	10 30 Slow		1778	3810	Vertisol	8400	F	Andes.Aglm	Kaol/Montm	5.2	43	33	20	18	0.2	0.8	77	1.2	0.2	11
25	Assor	C	10 20 Slow		1778	2540	Ultisol	2700	mS	Dac/Latosol	Kaol	5.2	35	18	10	9	0.3	1.2	50	2.5	0.2	16
38	Balambouche	gtVCL	2 8 Slow in subsoil		1524	2286	Mollisol	1000	S	Si pan/Dac	Montm	6.1	7	6	5	1	0.1	0.3	79	1.2	0.1	8
39	Balambouche	gtVCL(s)	2 8 Slow in subsoil		1524	2286	Mollisol	930	mS	Si pan/Dac	Montm	5.7	11	9	6	1	0.4	0.6	77	1.6	0.1	8
21	Belfond	CL	10 30 Moderate to rapid		2413	3048	Alfisol	350	S	Calc.tuff	Shallow	6.7	55	57	38	19	0.2	1.2	100	2.0	0.2	53
12	Becure	L	15 30 Rapid		1270	1524	Mollisol	2600	S	Colluv	Halloysite	5.7	36	30	21	11	0.1	0.5	83	2.8	0.3	10
20	Bocage	stC	25 35 Rapid		1778	3048	Mollisol	600	S	Dacitic ash	Allophane	6.1	27	28	18	6	0.5	1.5	100	8.0	0.5	30
9	Calfourc	SIL	10 20 Rapid		2540	4064	Inceptisol/Andisol	10200	S	Dac/Latosol	Halloy/Kaol	6.5	30	14	10	4	0.5	0.3	46	4.8	0.6	24
24	Canelles	C	5 25 Moderate		1778	3048	Inceptisol	4100	S	Colluv	Halloysite	5.0	14	4	2	2	0.2	0.7	30	1.5	0.2	0
10	Casteau	grboSIL	5 25 Rapid		2413	2687	Inceptisol/Andisol	3200	F	Dac/Latosol	Alloph/Kaol	5.7	29	26	21	5	0.1	0.7	90	1.7	0.4	50
26	Cochon	SiCL	10 35 Rapid		2032	3810	Inceptisol/Andisol	540	mS	Alluvium	Mixed	5.6	59	52	31	21	1.1	1.0	87	3.5	0.3	13
28	Degbs	SIL	0 1 Extremely Slow		1778	2159	Vertisol	1700	F	And/Bst Ag	Montm	5.8	27	23	11	9	0.7	1.0	84	4.0	0.4	22
43	Delomel	C	5 25 Slow to very slow		1524	1905	Inceptisol	280	S	And/Bst Ag	Montm/shlw	6.7	47	44	32	11	0.6	1.6	93	5.0	0.3	25
16	Dennyry	C	10 20 Slow to very slow		1270	2032	Vertisol	8000	mS	Dac.ash/fgl	Halloysite	6.0	15	13	8	4	0.4	0.3	80	2.4	0.2	20
44	Dugard	C	5 15 Moderate to slow		1270	1651	Vertisol	10600	mS	And/Bas lav	Hall/Montm	6.5	52	47	33	12	0.7	1.8	89	1.9	0.2	9
48	Esperance	C	10 30 Slow to very slow		2032	2540	Inceptisol	3100	S	And/Bst Ag	Montm/shlw	6.5	99	97	73	26	1.6	4.5	97	2.2	0.2	105
32	Falaise	stL	15 35 Rapid		1270	2794	Mollisol	1500	mS	And/Bst Ag	Halloysite	6.0	28	25	15	11	1.1	1.4	90	5.0	0.5	20
46	Franciou	stC	5 25 Rapid		1270	1778	Inceptisol	10100	F	And/Bst Ag	Montm/shlw	5.9	68	65	35	31	0.4	1.4	96	1.8	0.1	55
1	Garrand	CL	5 25 Rapid		1905	2540	Inceptisol	340	S	And/Bst Ag	Montm/shlw	6.6	37	37	26	12	1.0	2.0	100	5.0	0.4	15
31	Gommier	stL	5 25 Extremely Rapid		1270	2032	Vertisol	4800	mS	Colluv	Halloysite	6.1	18	17	15	5	0.1	0.7	99	1.6	0.2	81
45	Hardy	C	5 25 Moderate to slow		1270	1778	Inceptisol	860	S	Alluv	Mixed	6.2	15	12	9	3	0.4	0.6	83	1.9	0.2	1
13	Haut	CL	10 25 Rapid		2032	2540	Inceptisol	4700	S	And/Bas lav	Montm	4.6	47	10	5	4	0.2	0.3	20	2.0	0.2	5
19	Ivrogne	stC	20 35 Rapid		1778	3048	Inceptisol	1100	mS	Andes.ash	Allophane	5.6	57	51	43	13	0.1	0.7	90	1.3	0.2	16
30	Jalousie	C	2 6 Slow to very slow		2286	2540	Inceptisol	2800	S	Colluv	Halloysite	5.9	25	21	11	11	0.2	0.7	86	3.0	0.2	14
15	Jambette	stSIL	5 25 Rapid		1524	2286	Inceptisol/Andisol	1000	S	Dacitic ash	Allophane	5.7	21	10	2	2	0.4	0.3	50	2.0	0.2	0
5	Jean Baptiste	SiCL	15 35 Rapid to moderate		2032	3810	Inceptisol/Andisol	2800	S	And/Bst Ag	Halloysite	5.5	10	5	3	2	0.1	0.7	60	2.3	0.2	7
49	Latlille	CL	0 2 Moderate		1524	2032	Alfisol	720	mS	Si pan/Dac	Montm	5.8	11	9	6	3	0.1	0.4	77	1.5	0.1	6
6	Mabouya	SiC	18 25 Slow to very slow		2286	3048	Inceptisol	4700	mS	Si pan/Dac	Montm	5.7	17	12	7	4	0.1	1.5	80	1.6	0.2	1
11	Mahaut	SiCL	5 25 Rapid to moderate		1905	2540	Inceptisol	3200	mS	And/Bst Ag	Kaolinite	5.2	16	9	6	4	0.1	0.6	60	3.0	0.3	15
2	Marquis	C	15 25 Rapid to moderate		1905	2540	Inceptisol	10	S	And/Bst Ag	Halloysite	5.6	24	19	14	5	0.6	0.6	80	2.8	0.2	6
41	Michel	gtVCL	1 5 Slow to very slow		1524	2032	Alfisol	7400	S	Andes.ash	Allophane	5.0	20	4	3	1	0.3	0.7	20	2.4	0.2	8
47	Micoud	gtVCL	5 25 Slow		1524	2286	Inceptisol	1300	F	Alluvium	Mixed	6.0	31	30	21	10	0.1	1.2	95	2.2	0.2	13
3	Moreaau	C	15 25 Rapid to moderate		2032	3048	Ultisol	1800	S	Colluv	?Alloph/Hal	6.0	16	15	11	4	0.1	0.6	93	1.5	0.2	6
7	Parasol	C	30 40 Rapid to moderate		2032	2540	Inceptisol	700	S	Alluvium	Halloysite	5.8	60	55	42	12	0.1	0.9	92	1.8	0.2	20
14	Panache	SiC	25 40 Moderate to rapid		2032	2540	Inceptisol/Andisol	1700	S	Colluv	Halloysite	6.1	18	16	12	3	0.6	0.9	86	2.3	0.2	3
51	Paiye	SiC	0 2 Very slow		1524	1778	Alfisol	2700	S	Alluvium	Mixed	4.8	24	18	15	4	0.1	0.3	74	1.3	0.1	29
29	Quillesse	SiC	5 15 Slow to very slow		3048	4064	Inceptisol	1700	S	Si pan/Dac	Montm	5.7	19	16	9	7	0.1	0.8	94	1.3	0.1	10
22	Rabot	C	15 25 Rapid		2286	3048	Alfisol	400	mS	Alluvium	Mixed	4.7	26	17	15	3	0.1	0.3	70	2.8	0.2	60
50	Raveneau	C	15 25 Rapid		2286	3048	Alfisol	2700	S	Peat/Alluv	Peat/Mixed	5.4	28	26	17	9	0.2	0.6	86	2.1	0.2	18
8	Regnier	stC	20 35 Rapid		2032	2286	Inceptisol	12100	S	Dac.ash	Alloph (v.s)	6.5	99	99	99	9	0.4	3.5	94	17.0	1.1	30
18	Richerfond	stSIL	0 1 Moderate to rapid		1778	2286	Alfisol	400	mS	And/Bst Ag	Halloysite	4.7	33	11	6	5	0.4	0.4	30	4.0	0.4	2
40	Rozette	gtVCL	2 15 Slow to Moderate		1397	2032	Fair															
27	Soucis	SiCL	0 2 Slow to very slow		1778	3048	Alfisol															
37	Troumasse	L	0 2 Rapid		1524	2286	Good to Fair															
52	Vanard	Peat	0 2 Water-logged		2032	2286	Good to Fair															
36	Venus	L	20 35 Rapid		2032	3048	Fair to Poor															
4	Warwick	C	20 35 Moderate		2286	3810	Good															
23	Zenon	grboLS	2 8 Rapid		2286	2540	Fair															




Sources: Stark et al, 1966; Smith G.,1981; HTS,1996 based on Colmet-Daage et al, 1973 & Hardy, 1971.

ST LUCIA: AGRO-ECOLOGICAL ZONES

Figure 2.3

SCALE 1:100,000

Compilation Note:
 i) Soils boundaries based on Stark et al, 1966; re-analysed according to mineralogical divisions of ORSTOM, c.1970 by the IITS/MMI (1996);
 ii) Agro-climatic zoning by IITS/MMI, 1996, based on data of AISED, MAFF&I;
 iii) Watershed boundaries (37) from analysis & photo-reduction of 1:25,000 map by IITS/MMI.
 For full legend & explanation, see accompanying tables.

Climatic Zone boundaries: 
 Watershed boundaries: 
 Rainfall recording station: 

AGRO-ECOLOGICAL ZONES:

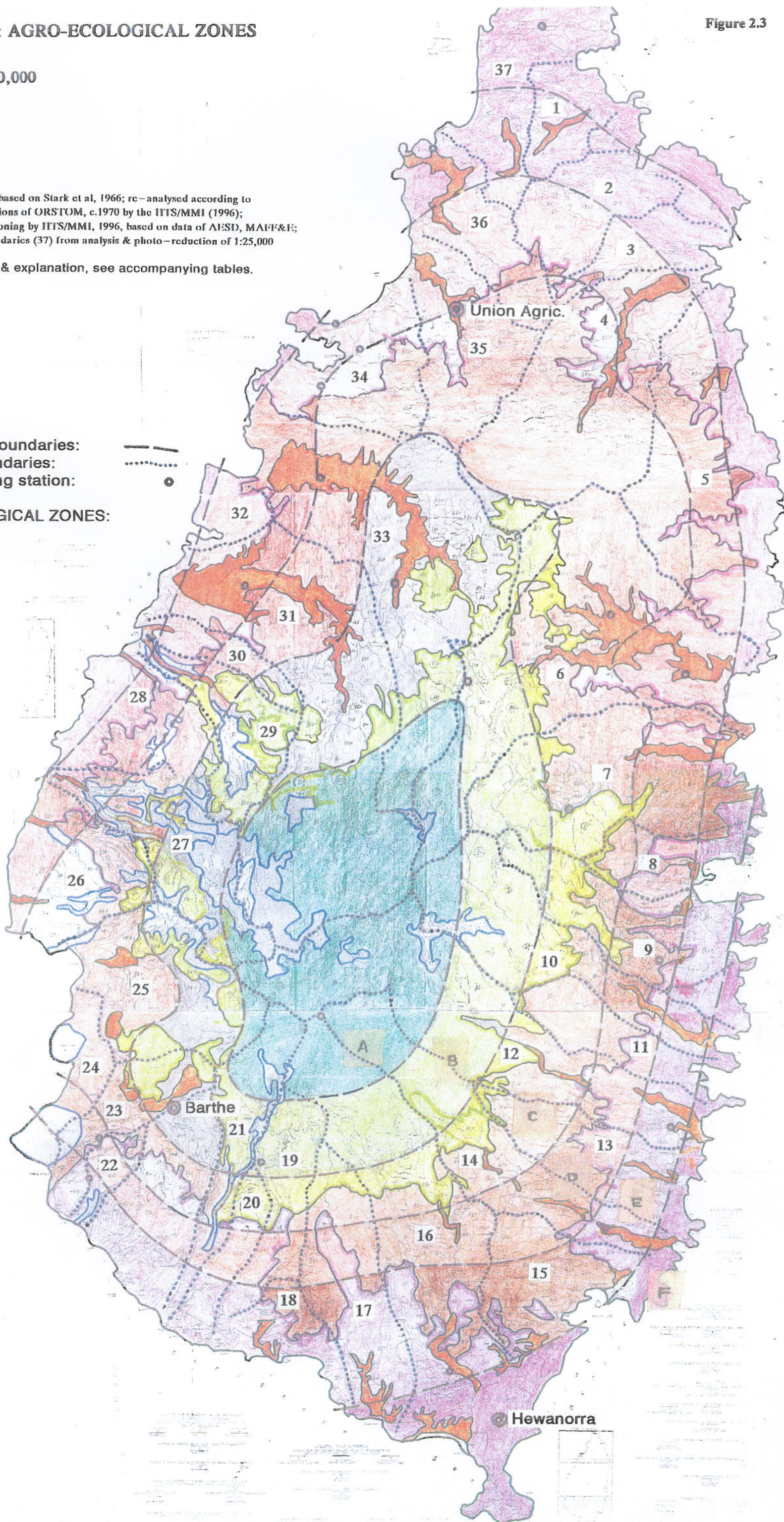
-  Ah
-  Bh
-  Ch

-  Bk
-  Ck
-  Dk
-  Ek

-  Dm
-  Em
-  Fm

-  O

-  S



- **Montmorillonite: 'm':** (shades of red). This group represents the drier and some intermediate areas. Soils are clayey in texture, some showing appreciable stone or boulder contents, and clays show large cracks during the dry season, being characteristic of the montmorin group. CEC values and exchangeable cations are high: often Mg/Ca ratios are high, and sometimes inverted. In drier areas, particularly on the Windward coast, Na concentrations in the subsoil are high. Soils are often shallow, and overlie silica duripans which severely restrict root and water movement.

Natural vegetation is dry forest and scrub woodland. Soils are commonly more erodible than the other groups: however, more commonly the soils are not cultivated, and the presence of natural vegetation and the lower rainfall intensities experienced by these soils means that actual erosion is less than for inland areas.

Although chemical fertility of these soils is higher than for the other upland groups, their shallow depth and occurrence in drier areas means that they are of much lower value agriculturally. In many areas they should be zoned for building: however, the montmorin clay materials should be removed, and foundations made on hard underlying materials as these clays are subject to considerable heave movements, particularly where profiles are deeper and tree roots are present.

2.2.3 Soil Infiltration Rates

Surface soil infiltration rates represent the critical soil parameter determining how much rainwater will enter the soil, and how much will run off for the event of each rain shower.

Measurements on surface infiltration rates for upland soils appear not to have been undertaken in St Lucia, and thus a programme for measurement by sprinkler infiltrometer was adopted for this project. This was subsequently used in the field trials programme as a key characteristic of the soils under different banana trash management regimes. The sprinkler infiltrometer, rather than the double ring infiltrometer, was chosen in that it simulates rainfall more closely. Full details of the method used and results obtained are given in Annex 4 and Annex 7.

Results of the infiltration tests showed that there was a large variability of infiltration rates over short distances, but a strong correlation between high infiltration rates and presence of trash cover, earthworm presence and worm channel density. Comparing trash-covered with bare soil surfaces, initial infiltration rates (first 15 minutes) were increased from an average of 48 to 100 mm/hour; terminal rates (after 90 mins) were increased from an average of 17 to 42 mm/hour. The average amount of water infiltrated over the 90 minute trial period (60+30 minutes) was 40 and 88 mm respectively.

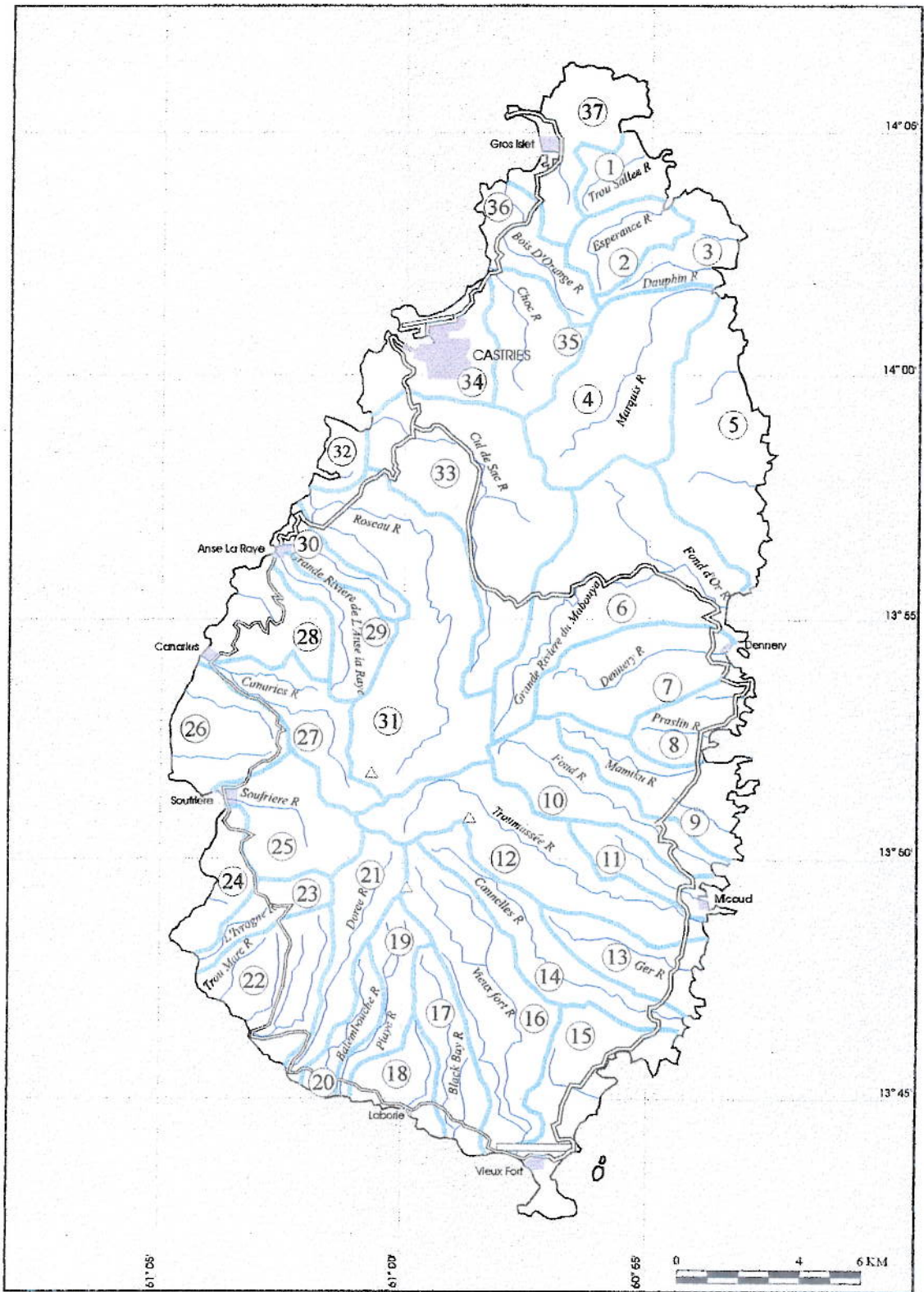
Extrapolating these average infiltration rates to the TSD event (using the Union Agricultural Station rainfall intensity figures), the immediate surface run-off would have been 160 and 72mm respectively for bare and trash covered surfaces, out of a total rainfall figure of 270 mm measured over the 8-hour period. The balance of 88 mm would have been temporarily held in the macro-pores in the soil, and released over the following hours and days as lateral sub-surface water flow through the soil profile.

2.3 WATERSHEDS AND THEIR CHARACTERISATION

A division of the island into component watersheds is fundamental to any watershed management and environmental project. Physical impacts of development within any individual watershed area (eg in terms of run-off, flooding, siltation) is confined to the limits of that watershed, and the adjoining coastal areas.

The map of the 37-watersheds as delineated by the UN Water Resources Exploration & Assessment Project, 1986, was used as the basis for this study, and this is presented in **Figure 2.5**. Statistics for these watersheds are given in **Table 2.5**. The Consultants have added to this table a characterisation

Watersheds of St Lucia



File: HYDRO/ENM/CDR

of each of the watersheds according to the agro-ecological zones defined. As can be seen, only 10 watersheds show significant areas within the highest rainfall zone (A), while a further 6 watersheds show significant areas in Zone B. Many of the smaller watersheds have their head-waters in drier agro-ecological Zones, and such is the case for the five northern watersheds (1,2,3,36,& 37), and watersheds 8,13,18,20,26, and 32. These drier watersheds often show no flows during the peaks of the dry season.

As can be seen from the table, the two watersheds selected for the pilot study (Cul de Sac and Dennery) both cover a very wide range of agro-ecological zones.

Land Use Characterisation of the watersheds is given in **Table 2.6**, which is based on the work of Roche Itee, 1993. It should be noted, however, that this work was based on interpretation of satellite imagery, effectively at 1:50,000 scale, and the land use categories separated are by nature rather imprecise. However, this is the only reasonably up-to-date comprehensive land use coverage of the island.

2.4 POPULATION AND LABOUR FORCE

St. Lucia has experienced a high population growth rate in the post-World War II period. Between 1960 and 1970, the population is estimated to have grown by 17%; between 1970 and 1980, the estimated increase was 14%; and between 1980 and 1990, some 16%. The effect of this rapid growth over several decades means that St. Lucia will continue to have a relatively young population over the next three to four decades, even if the birth rate were to decline significantly in the short term. The country is therefore at the stage of transition in which the population is very young, and contains a large number of women of child bearing age. The provisional estimate of the population at the end of 1994 was 142,689. The annual population growth rate is estimated at about 1.9%. Two-thirds of the population is rural, and average household size is between 4 in urban and 6 in rural areas. Over 40% of households are headed by women: 46% in urban areas and 38% in rural areas. The outline demographic details for St. Lucia are presented in **Figure 2.6**, and the location of centres of population in relation to the Watershed boundaries, is given in **Figure 2.7**. A listing of these main population centres by watershed is given in **Table 2.6**.

The employed Labour Force is distributed as follows:

25% employed in agriculture, 12% in manufacturing, 12% in trade, 9% in construction, 8% in tourism, and 34% in other services.

The unemployment rate has gradually increased over the years and is currently estimated at 20% island-wide with record heights between 32% and 35% for the districts of Anse-La-Raye, Choiseul and Laborie. The proportional contribution of the 15-19 year age group to the employed labour force is 7% whereas their share of the unemployed labour force is 27%. About 55% of the unemployed labour force is below 24 years of age. However, official unemployment figures may be regarded as the tip of an iceberg, with many of the work force not included in the figures.

The labour market issues relate to relatively high wages, particularly for agricultural labour, skills mismatch and low productivity. The market for skilled labour is tight because of the expansion of construction activities. Daily wage rates for unskilled labour are high and average EC\$35. The adult literacy rate is estimated at 82%, but according to the findings of the 1993 Labour Survey, only 1.6% of the total population attained university education with 53% completing primary and 15% completing secondary school. The government recognises that there are insufficient school places at the secondary level: during 1992 secondary schools were able to accommodate only 50-60% of the total number of students aged 11 and 12.

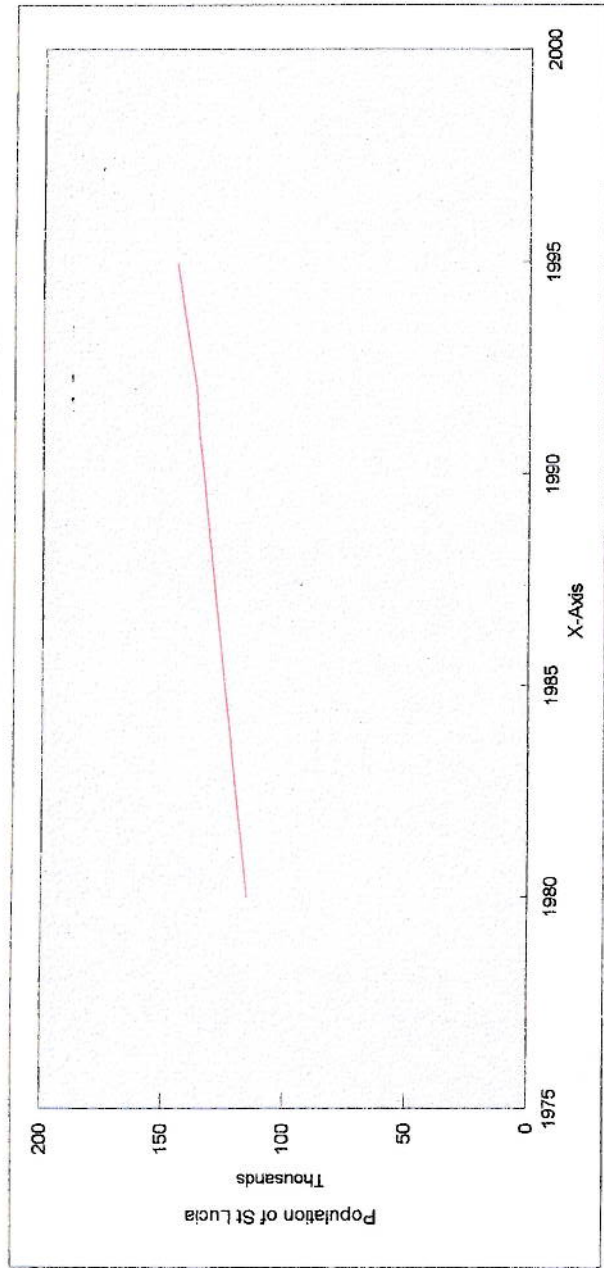
TABLE 2.6: AREAS OF LANDUSES (ACRES) WITHIN EACH WATERSHED

Land Use Category	WATERSHED NUMBER																				TOTAL	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Natural Forest (1)	0	319	104	1809	1567	2454	971	264	348	2160	52	2770	0	704	0	927	91	84	156	0		
Mangrove	27	12	0	12	20	27	0	12	27	40	178	156	25	12	245	0	7	7	0	0		
Plantation Forest	0	0	0	82	54	208	0	27	0	10	0	336	0	210	0	74	0	0	0	0		
Scrub Forest	1006	998	1161	507	2701	482	284	198	741	136	274	301	877	558	1762	418	504	324	195	0		
Grass and Open Woodlands	222	0	166	0	109	20	119	20	131	0	12	27	378	126	514	376	339	106	0	0		
Mixed Farming	232	521	351	1488	1562	2486	2481	603	852	862	568	1055	469	941	746	1960	1337	549	870	193		
Intensive Farming	15	388	541	3109	798	3121	1102	1280	1352	937	531	2854	1171	1488	835	2891	927	111	1011	719		
Farming Densely Vegetated	0	0	0	15	0	0	0	0	183	250	450	173	52	0	0	119	91	32	74	324		
Flatland Intensive Farming	0	25	0	185	0	801	0	0	0	0	0	0	0	0	44	188	0	0	0	0		
Flatland Agricultural Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Eroded Agricultural Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Rural Settlement	52	158	35	519	0	450	0	20	284	47	0	89	363	294	12	166	138	0	104	25		
Urban Settlement	67	0	0	0	0	170	277	52	0	54	27	0	0	0	1011	245	336	111	7	0		
Rock and Exposed Soils	35	7	32	15	329	12	0	0	20	7	44	20	15	0	185	0	0	0	0	0		
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
TOTAL (Acres)	1656	2428	2390	7741	7140	10231	5234	2476	3938	4503	2136	7781	3350	4333	5354	7364	3770	1924	2417	1261		
Land Use Category	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	TOTAL	%			
Natural Forest (1)	321	0	91	472	731	951	1762	1352	1144	526	5041	133	1490	54	381	536	91	29856	19.6			
Mangrove	0	0	0	0	0	0	0	12	12	0	7	7	7	0	0	7	7	866	0.6			
Plantation Forest	25	0	0	0	0	0	0	0	0	0	27	0	138	0	5	0	0	1196	0.8			
Scrub Forest	0	91	91	274	0	796	72	677	12	106	59	351	20	262	321	450	1562	18571	12.2			
Grass and Open Woodlands	0	0	0	25	84	0	0	27	0	0	0	0	0	72	0	86	257	3216	2.1			
Mixed Farming	1302	1191	235	170	1522	944	1374	1080	739	529	2071	35	2179	408	768	551	558	35782	23.5			
Intensive Farming	709	2110	766	101	919	217	188	44	292	133	3496	52	3852	467	1132	423	64	40146	26.4			
Farming Densely Vegetated	348	84	336	343	652	304	163	12	27	0	5	0	193	0	12	0	0	4242	2.8			
Flatland Intensive Farming	0	0	0	0	0	0	0	0	0	0	1023	0	929	0	72	0	0	3267	2.1			
Eroded Agricultural Land	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.0			
Rural Settlement	114	573	86	35	193	86	25	20	0	101	351	91	551	119	373	264	84	5822	3.8			
Urban Settlement	25	432	0	101	178	12	35	20	0	22	106	324	657	2098	124	499	1016	8006	5.3			
Rock and Exposed Soils	0	0	27	250	32	7	0	0	0	0	0	0	0	7	0	0	52	1096	0.7			
Water	0	0	0	0	0	0	0	0	0	0	69	0	79	0	0	0	86	234	0.2			
TOTAL (Acres)	2844	4481	1637	1771	4311	3317	3619	3244	2226	1417	12255	993	10095	3487	3176	2828	3777	152305	100.0			

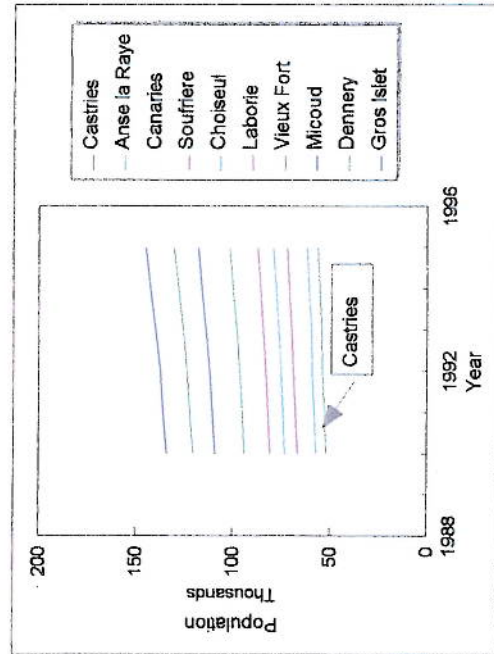
Source: Roche Itee, 1993. Note 'Mixed Farming' Class may include significant areas of non-cultivated land.

Figure 2.6

Population Growth in St Lucia over the last 20 Years



Population increase by District



Population distribution by District

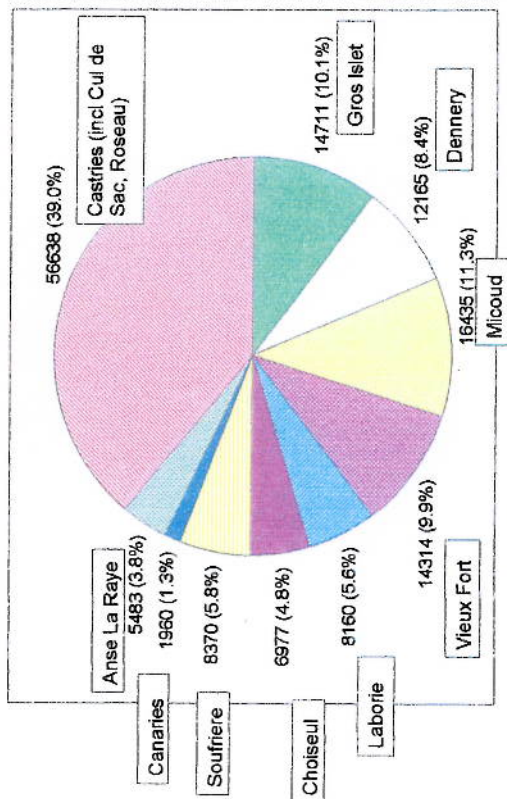
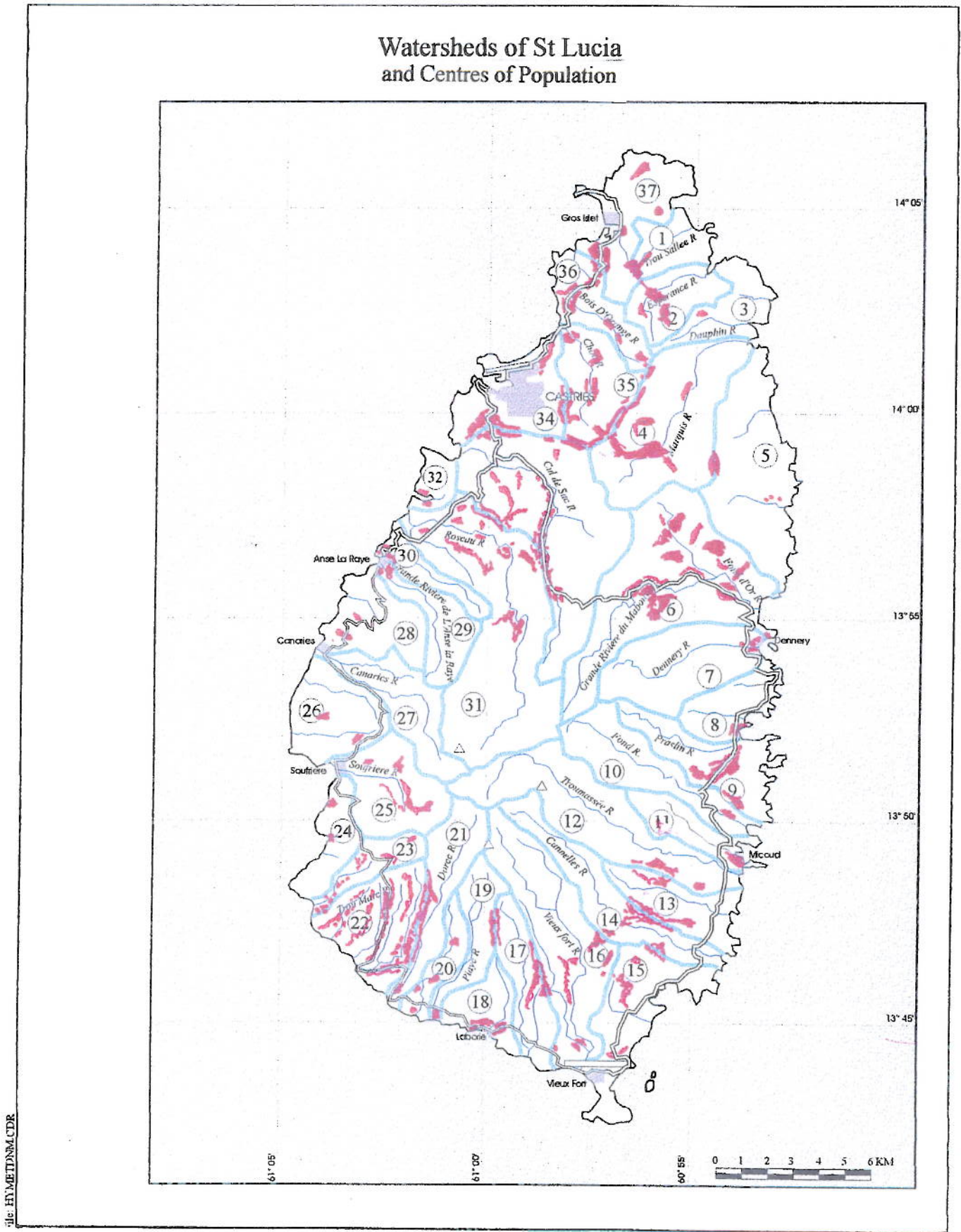


Figure 2.7



file: HYMETDNNM.CDR

KEY TO FIG 2.7: MAIN AREAS OF POPULATION BY WATERSHED

Watershed Name (River Basin) No.	Watershed Area No. km2	Main Towns/Villages
Sallee/ Lapins	1	6.7 <i>Sparse</i>
Esperance	2	9.7 Monchy / (la Borne)
Trou Grauvail Dauphin	3	10.0 <i>V. Sparse</i>
Marquis	4	31.0 Boguis / Garand / Talvern / Chassin / Des Bollieres / Fond Asson / (Babonneau)
Grande Anse Louvet	5	29.2 <i>V. Sparse</i>
Fond D'Or // Mabouya	6	41.0 Thomazo / Grand Riviere / La Belle Vie / Riche Fond / Grand Ravine / La Caye La Resource / Demiere Riviere / Au Leon
Dennerly	7	21.4 Dennerly
Riviere Galet des Trois Islet	8	11.0 Praslin
Mamiku // Patience	9	16.0 Mamiku / Mon Repos / Patience / (La Pointe)
Fond	10	18.1 Malgretoute / (La Pointe)
Voilet	11	8.6 <i>V. Sparse (Micoud)</i>
Troumasse	12	31.7 (Micoud) / Ti Rocher / Dugard / Beauchamp / Moreau Estate
Micoud Ravine Bethel	13	13.1 Planard / Des Blanchard / La Courville / Anse Ger / (Blanchard) / (Desruisseaux)
Canelles	14	17.3 Vige / De Mailly / (Blanchard) / (Desruisseaux) / (Belle Vue)
Rouame // St Urbain	15	22.8 St Urbain / Pierrot / Cacao
Vieux Fort	16	28.8 Vieux Fort / La Tournay / Derriere Morne / La Resource / Hope Estate / Coolie Town / Grace / Joyeux / (Belle Vue)
Black Bay	17	15.2 Angier / Gentril / Mac Domel / Banse
Laborie	18	5.5 Laborie / Sapphire / Mome Paul
Playe	19	9.6 Playe / La Perle Estate / Annus / Londonderry / Gertrine / Fond Berrange / Daban / Ginaud / (Saltibus)
Balembouche	20	5.2 Balembouche / Balca / Gayabois
Doree	21	11.1 Doree / Lamaze / (Debreuil) / (Roblot) / (Saltibus)
Choiseul	22	18.1 Choiseul / Reunion / La Fargue / Sauzay / Cafeire / Dugard / Mavay / Mome Jacques/ Victoria de Ville / Belle Vue / Mongouge / Ponyon / Martin / La Riche / Mome Sion / Fiette / Esperence / Derriere Morne / Bois d'Inde Franciou / (Debreuil)
L'lvrogne	23	6.5 Delcer / L'lvrogne / La Ponte / Union Vale / Chateau Belair / Strangs / Beausejour
Pitons	24	7.1 Plat Pays / Jalousie
Soufriere	25	17.2 Soufriere / Ruby / La Perle / Diamond / St Phillip / Fond St Jaques
Mamin // Mahaut	26	13.7 Desruisseaux / Colombette / Bouton
Canaries	27	14.6 Canaries
Anse la Verdure	28	13.1 Anse la Verdure / Theodorine
Grande Riviere de Anse-la-Ra	29	8.9 Anse la Raye (S) / sparse
Petite Riviere de Anse-la-Ray	30	5.7 Anse la Raye (N) / Au Tabor / sparse
Roseau	31	49.1 Millet / Dame de Traversay / Durandean / Sarot / La Treille / Vanard / Jacmel / Jean Baptiste / Mome d'Or / Belair / perou / Fond Manger / Coolietown / Massacre / Roseau Distillery / Derriere Lagoon / Bois d'Inde / (La Croix Maingot)
Mt Bellevue	32	4.8 Marigot
Cul de Sac	33	40.9 Ciceron / Trois Pitons / Mome St Joseph / Soucis / Barre Denis / (La Croix Maingot) / Deglos / Crown Lands / Marc Marc / Bexon / L'Abbaye / Ravine Poisson
Castries	34	14.3 Castries / (Bocage)
Choc	35	12.7 Cabiche / Balata / Union / Choc / Girard / (Bocage)
Bois d'Orange	36	11.3 Marisule Estate / Grande Raviere / Monier
Cap	37	15.4 Cap Estate / Gros Islet / Massade Estate / Reduit
Totals	616.4	

The statistics reveal that generally the number of unemployed persons reduces significantly as educational attainment increases. Consequently the greatest number of unemployed persons have either passed only a limited number of standard examinations or have not passed any examinations. Women are better trained for the formal job market than their male counterparts.

Overall, a high proportion of the population is under thirty years old (65%). This group experiences severe unemployment, poor educational opportunities, particularly for higher education, increasing incidence of drug abuse and addiction, a high incidence of teenage parenthood, and alienation from the decision making process. Young people are generally reluctant to get involved in agricultural production or indeed any traditional rural employment activities, and consequently there is rural-urban migration and a dissatisfied youth population in the rural areas. With the decline in the rate of growth of the economy, and with the limited prospects for a substantial expansion in investment in the foreseeable future, there is likely to be continuing high levels of structural unemployment in the informal sector and in rural communities. It is certain that if the birth rate remains at its present high level, the population will double in less than forty years. In the past, out-migration provided a safety value, but this option is currently not significant and there seems little prospect for changes in immigration policy on the world scene, especially in popular destination countries. Unfortunately it is very easy to overlook the fact that the slope of St. Lucia's population growth curve has been quietly growing steeper and this trend seems set to continue. Population densities will rise, as will difficulties with youth alienation, crowding and the maintenance of social peace. On top of this, natural hazards such as hurricanes and tropical storms strike the island sporadically causing substantial setbacks to the economic development through damage to economic and social infrastructure.

2.5 THE ECONOMIC SITUATION

The development of the St. Lucian economy has been largely constrained by its small population and limited natural resource base. No mineral assets of economic importance have been identified but the country's fertile volcanic soils provide the resource base for agricultural development, long the dominant economic sector. Other natural resources are now being exploited in support of tourism which today rivals agriculture as the country's lead economic growth sector. The period 1960's to 1970's was characterised by relatively high rates of overall economic growth, but the economy experienced a slowdown beginning in the late seventies and continuing through the 1980-82 period. This decline has been attributed to a combination of factors, including the international recession, a series of destructive natural disasters, and political uncertainty. However, in the period from 1983 to 1989, St. Lucia experienced real growth averaging nearly six percent, largely as a result of increases in banana production and tourist arrivals and high levels of construction activities. Since 1990 there has been a slowdown with an average annual rate of growth declining to 3.9%.

In 1994, according to estimates by the World Bank, St. Lucia's gross national product (GNP), measured at average 1992-1994 prices, was US\$ 501 million, equivalent to US\$ 3,450 per head. The GDP share of the tourism sector, measured by hotels and restaurants, increased from 8.4% in 1977 to 11.7% in 1995. This is reflected by a steady increase in total visitors from 151,000 in 1985 to 436,000 in 1995. The contribution of agriculture (mainly banana for export) declined in the period 1977-1995 from 17.5% to 11.2%. Government Services still provide a large share of the GDP at 13.6% in 1995. The share of the manufacturing sector fluctuated somewhat, increasing from 6.3% in 1977 to as much as 9% in 1987 before falling to 7.0% in 1995. The development of the country's physical infrastructure resulted in the steady growth of the construction sector from 4.4% (1977) to 8.5% (1995) of real GDP. Other important sectors of the economy are transport and communication (18%), wholesale and retail (13%) and banking and insurance (10%).

The agriculture sector is the largest single employer in the country representing 25% of the employed labour force. Most of the employment is attributed to the banana industry, given the dominance of the sub-sector with 12% of the GDP (banana exports only) and almost 50% of total export earnings. The banana industry comprises not only the production sector (104,00 tonnes in 1995) but also processing and packaging. The highly developed marketing and distribution structure within the domestic economy, has resulted in the substantial linkage between the banana industry and a number of other sectors, e.g. transport, storage and communications, including port operations. Therefore, the total contributions of the banana sector, to GDP, including all related economic activities and services is far higher than the face value of production and can be estimated at about 30-40% of GDP. Any difficulty in the banana sector reverberates quickly and widely to other sectors of the economy and has a depressing effect on incomes and employment in those sectors. The country's dependence on banana poses a serious challenge to economic and social stability on the island. Beginning in 1993, the pound sterling began a depreciation against the US dollar and by the end of 1993 the pound had depreciated by about 20% relative to year end 1991. The resulting fall in banana prices combined with considerable uncertainty facing the industry due to changing banana policies in the European Union have led to economic hardship for small farmers over the past four years, a situation which is likely to continue. The present strength to sterling can bring only a temporary respite.

The level of social dissatisfaction with its potential for social unrest first became evident in 1993, when a three day strike by banana farmers, protesting about low prices, led to violent clashes with the police and two deaths. Any further deterioration of the banana sector could have serious social consequences and any analysis of economic prospects must take this into account.

2.6 THE DOMINANCE OF BANANAS IN THE AGRICULTURAL ECONOMY

Just one economic indicator is sufficient to highlight the predominant position of bananas: in 1995 the value of banana exports was EC\$ 128.1 million, equal to 47% of total export earnings and 89% of agricultural exports. Apart from this obvious impact on the economy, other sectors such as input suppliers, packaging, transport, road construction and port handling are all involved, and the Government benefits through taxes, duties and port handling charges.

Unofficial estimates put banana cultivation at 15,000 acres, out of a total cultivated area of 39,000. Preliminary results of the 1996 Agricultural Census put the figure at 19,000. Assuming an average of 5.5 members per household and around 5200 SLBGA registered banana farmers, the number of people fully or partly dependant on banana production can be estimated at 29,000. When including a conservative average of 0.2 permanent paid workers per acre, this figure increases to 32,000, representing around 39% of the total labour force or 1 in 3 of the inhabitants of St. Lucia.

Bananas are popular for a number of reasons. The crop provides a regular income throughout the year, has a well developed marketing infrastructure, a guaranteed market, and price. This reliability makes access to credit easy. If affected by strong winds or storms the crop is easy to reestablish at minimum cost. Finally the crop is largely immune from praedial larceny.

Various statistical sources, supported by the Consultants' reconnaissance survey, put the size of banana holdings between 3 and 8 acres (average 5.5 acres). The 1993 WINBAN survey of banana growers concluded that 65% of all growers depend entirely on bananas as a source of income and a further 30% derive more than half their income from bananas. Large farms are strongly reliant on banana income, but smaller hillside banana farmers often have other sources of income. The reconnaissance survey showed that farm income was used mainly to cover household expenses and some agricultural inputs. Very little of the income was re-invested in the farm.

The profitability of bananas is highly variable and is influenced by a whole range of factors. A typical hillside farmer having 3 acres of bananas and using few inputs, a yield of 7 tonnes per acre and a sale price of 31 cents per lb. would expect a return to his own labour of EC\$ 6,885. The lack of alternative employment opportunities probably justifies his decision to stay in production. At the other extreme, a valley bottom farmer using higher inputs and obtaining a target yield of 13 tonnes per acre would get returns of EC\$ 2,620 from his bananas and EC\$ 4,981 from his labour, total of EC\$ 7,601 per acre, or, for an average valley bottom farm of 5.5 acres, EC\$ 41,805.

From a National perspective, SLBGA costs must be added. These are: 13 cents per pound for boxes, 2.2 cents for leafspot control, 2 cents for insurance and 5 cents for administration. Using variable costs of production ranging from 22 cents to 31 cents per pound, the total economic cost of production ranges from 44.2 to 53.2 cents. Seen against the recent average SLBGA sale price of 53 cents the reason for the massive debt accumulation (EC\$ 40 million +) is obvious.

The high unit cost of production is influenced by many factors, most significant of these are the cost of inputs and high labour costs, particularly on steep land and on land some distance from a motorable road. With variable costs ranging from 22 cents/lb. on flat, high producing land to 31 cents on marginal hillside farms, some structural adjustment within the banana industry is inevitable. The Certified Farmer Programme which aims at rewarding farmers producing high quality fruit, cannot because of production criteria stipulated as part of the package, accommodate many small producers in marginal areas. This means in effect that the benefits of the programme will go mainly to farmers occupying the limited area of flat valley bottom land. Even so, it is doubtful whether even these farmers can compete with Dollar banana producing countries on production costs.

During the past five years the profitability of bananas has been falling, and without doubt some farmers are losing money.

To complete the picture, banana production in St. Lucia must be viewed from a global perspective.

Between 90% and 97% of Windward Island bananas have traditionally been absorbed by the lucrative UK market, and have until recently, enjoyed protected status and preferential treatment. The UK together with other EU countries, has more recently seen a levelling off in demand, and since 1993, banana imports have been open to competition from dollar bananas from Latin-American. Recent WTO rulings which maintain that the protected market flouts free trade rules, make it somewhat unlikely that protection will persist beyond 2000 or 2002.

The consequences of this are serious. Faced with competition from more efficient producers of high quality fruit, the banana industry in St. Lucia has both to improve quality and reduce production costs, by raising yields. This again would seem to mitigate against the less efficient hill farmer.

A recent drive to improve quality has been successful and farmers have shown that they are willing and able to respond, but to raise yields will take longer and require some investment.

The message to St. Lucia is clear. Either the restructuring of the banana industry is done in a well planned manner by promoting alternative crops on steep marginal land with support where this is necessary, or to allow the situation to deteriorate leading to potential social unrest with ramifications on the important and growing tourist sector.

Chapter 3

3 BACKGROUND TO WATERSHED & ENVIRONMENTAL MANAGEMENT IN ST. LUCIA

3.1 INTRODUCTION

This chapter examines the background related to the management of the environment in St. Lucia. It covers the progressive deterioration and causes; TSD and its' impact on the economy; Government's present approach to environmental matters and people's perception. It goes on to look at institutions and legislation and sets out the Consultant's approach to the issue.

3.2 ENVIRONMENTAL ISSUES

Concern was being expressed since the mid-1970s that St. Lucia (and indeed the other volcanic Windward Islands) was becoming increasingly and dangerously dependent on one crop, and that this was leading to a suite of environmental problems:

- the crop was increasing grown in excessively steep areas, replacing forest and perennial tree crops, and leading to increasing erosion losses;
- Government was wrongly spending money on feeder roads in order to service these areas;
- feeder roads were encouraging yet more cultivation in adjacent steep areas;
- domestic water supplies (both in quality, and dry-season quantity) were being threatened by such cultivation and deforestation;
- flash run-off after rain events was becoming increasingly intense, causing flood damage in downstream areas, and worsening siltation in drainage channels, river beds, and the coastal ecosystems;
- Government, again wrongly, was spending money on deepening and straightening the river channels, further worsening the marine siltation problem and threatening the tourist industry.

There are yet more concerns to add to this list, some directly related to bananas (increasing soil acidity; problems with pesticide use) others more related to increase of population and solid and liquid wastes, but the above crop-related issues remain the dominant concerns. Such concerns have become even more prominent following the major calamities associated with Tropical Storm Debbie (TSD), and the events of 26th October, 1996. The problems related to TSD are discussed in the next section (3.3): a full discussion of all the Environmental Issues is given in Chapter 5.

3.3 THE ECONOMIC IMPACT OF TROPICAL STORM DEBBIE

The degradation of the environment is a gradual process but natural hazards such as hurricanes and tropical storms serve as periodic reminders of the actual degree of deterioration and bring with them enormous economic and social losses.

In the case of St. Lucia it took the painful experience of TSD in September 1994, to bring home the urgent need for improving the management of natural resources. The current Watershed and Environmental Management Project and its subsequent implementation provides the main thrust towards achieving improvements.

On September 10, 1994, Tropical Storm Debbie struck St. Lucia and incessant rain was reported as high as 15 inches over a ten hour period. This level of precipitation contrasted sharply with the average of 12 inches for the month of September in the previous five years. Moreover, heavy rains in the preceding weeks had already resulted in extensive soil saturation. The continuous intensive rainfall led to widespread run-off, flooding, and massive landslides contributing to the washing away of soil, trees and crops and contributing to the formation of debris which choked rivers and damaged adjoining farmland. As a consequence, the storm resulted in about 600 persons having to be placed in emergency shelters, extensive inundation of agricultural land, disruption of electricity supplies and

telephone services, road and airport closures, and unavailability of tap water to the entire population. Four deaths and several injuries were reported. The heaviest damage occurred in the areas of Dennery, Anse La Raye and Soufriere.

The total economic loss to the agricultural sector was estimated at about EC\$ 133 million or about EC\$ 153 million when including damage to related infrastructure (see Table 3.1). This represented 13-15% of the 1993 GDP. Nevertheless the agricultural sector bearing the burnt of the damage. Valley areas were most severely affected due to flooding and deposition of soil and debris stripped from the river banks or deriving from the steep hillsides in the watersheds. More than 400 severe landslides occurred especially on cultivated land in the steep hilly areas. Apart from the evident physical damage to crops and infrastructure, non-apparent losses included leaching/washing away of residual fertilisers and the consequences of continuous waterlogging. Estimates by the MAFF&E reveal that as much as 10% of productive land was lost due to land slip, severe erosion, and river re-location. While this remains the official record, subsequent reports suggested that losses could have been over estimated by as much as 10%, but there are no figures to support this.

Damage to crops involved the entire range of commodities grown on the island. Official government estimates indicated that almost 60% of the total acreage under banana cultivation had been affected. Of this, about 20% was so severely damaged that replanting was required consequently extending the period of full recovery to at least a year. The economic loss to December 1994 alone was equivalent to 18,000 tonnes of banana equivalent to EC\$ 32 million (at 1994 prices). The cumulative loss over the 18 months following the storm's impact was estimated at EC\$ 76 million. Furthermore, the economic loss in tree crops (especially coconuts, cocoa), fruits, root crops and vegetables accounted for another EC\$ 46 million. Losses in forestry were recorded in both natural and planted forests, mainly due to landslip. In fisheries, major loss was observed in terms of damage to fishing pots and facilities (buildings, boats etc.) and sediment flowing into the sea buried parts of coral reefs and marine fisheries habitats. In addition to the partial or complete destruction of crops and the siltation of drains and fields left strewn with debris, substantial damage to farming and forest infrastructure contributed to the total loss account. The economic costs of lost soil and forest resources, permanently damaged valley farmland, affected coral reefs (as well in relation to returns from tourism) and reduced fish catches have not been evaluated. In the livestock sector losses occurred through drowning of stock and destruction of pens located in the flooded areas.

Cost for the rehabilitation and reconstruction of water systems, bridges, roads and buildings/houses, i.e. general social and economic infrastructure were estimated at about EC\$ 50 – 60 million. Flood water and siltation caused extensive damage to all water intakes, precluding WASA from using its water catchments for water distribution to the public. The rehabilitation works comprised mainly the replacement of damaged pipelines and restoration of water intakes. Rehabilitation works for desilting and river training accounted for the bulk of the EC\$ 14 million spent under Phase 1 of the Saint Lucia Watershed and Environmental Management Project. The country's main reservoir project (Roseau Dam) was extensively damaged. Six bridges were totally swept away by the flood waters, while four others suffered significant damage. While the surface of most roads remained unaffected by the storm, landslides resulted in the collapse of road shoulders. Two main arteries, the Barre De L'Isle and the West Coast Road, collapsed in parts due to land slip. However, most of the road damage was recorded on feeder roads which adversely affected the transportation of agricultural produce. The housing sector together with community support facilities suffered severely. About 233 houses were damaged of which about 100 were rendered uninhabitable.

Table 3.1: Tropical Storm Debbie - Economic Loss Estimate of Agricultural Sector

Crops	Unit	Number	Unit Value (EC\$)	Total Value (EC\$ million)
Banana	acres	8120	9360	76.00
Tree Crops	acres	3600	5900	21.24
Fruit Crops	acres	2250	5000	11.25
Root Crops	acres	3300	4000	13.20
Vegetables	acres	190	6000	1.14
Total Crops				122.83
Livestock				
Cattle	head	300	2000	0.60
Pigs	head	600	400	0.24
Other	head	3318	95	0.32
Total Livestock				1.16
Forestry				
Natural	acres	800	10000	8.00
Plantation	acres	155	7300	1.13
Total Forestry				9.13
Fisheries				
Fishpots	units	3000	250	0.75
Nets	units	24	10000	0.24
Boats	units	4	29250	0.12
Engines	units	2	6000	0.01
Total Fisheries				1.12
Infrastructure/Facilities				
Farm roads	miles	80	50000	4.00
Tracks/paths	miles	23	5000	0.12
Forest roads	miles	1	75000	0.08
Drains	acres	6300	2000	12.60
Farm storage	units	83	2500	0.21
Field sheds	units	432	1500	0.65
Animal Pens	units	56	13600	0.76
Greenhouses	units	10	18000	0.18
Fish. Buildings	units	5	52000	0.26
Fish. ramps	units	1	85000	0.09
Drainage(Fish.)	units	1	15000	0.02
Fish ponds	units	12	4583	0.05
Total Infrastructure/Facilities				19.00
GRAND TOTAL AGRICULTURE SECTOR				153.24

Source: data derived from MAFF&E

On a conservative basis, the total economic loss as a result of the Tropical Storm Debbie was finally estimated at about EC\$ 250 – 270 million¹ or close to US\$ 100 million. This represents about 25% of the 1993 GDP. However, the above damage inflicted by the storm affected the economy not only by direct income loss to the private sector and the burden of enormous rehabilitation costs for the public sector, but led inevitably to reduce tax income for the Government, significant loss of foreign earnings, food shortages, increased food import bills and adverse social hardships.

The extent to which the extensive damage caused by TSD is attributable to inappropriate land-use and environmental mismanagement, is impossible to quantify, but there can be little doubt, that these factors contributed significantly to the scale of social and economic loss.

3.4 GOVERNMENT APPROACH TO ENVIRONMENTAL ISSUES

Faced by ample evidence of damage, there has been a tendency for GoSL to take environmental issues seriously following serious flood events such as TSD. However, in time the memory fades and the ever present infrastructure, health or social problems make prior demands on available Government resources. The pattern of neglecting the environment during less catastrophic times, is illustrated by the following:

- an Environmental Commission was first established in 1981, but faded away for lack of political support, only to be re-launched in June 1995 after TSD;
- the National Environmental Commission, the organisation now charged with overall responsibility for management of the environment had not been nominated by the end of 1997, although a National Environmental Action Plan (NEAP) has been agreed;
- Land Conservation legislation was first proposed in 1984, the draft Bill became available by the end of 1987 and the Act finally reached the statute books in April 1992;
- the Land Conservation Board (LCB) was finally appointed in 1995, again after TSD and met for the first (and only) time in November 1995;
- no LCB regulations have been formulated and the Board has no access to funds.

It is worth noting that in contrast exception to the above, the Office of Disaster Preparedness (ODP) which answers to the Office of the Prime Minister, is regarded both in St. Lucia and in the wider Caribbean as an effective organisation. The original National Emergency Advisory Council, changed its name to the National Emergency Management Organisation (NEMO) and meets once a year to decide on actions needed in the event of a hurricane or other disaster

Some of the reasons for ODP's comparative success include:

- dedicated staff;
- separate funding;
- visible role at times of natural and other crises;
- local participation (e.g. ODP Emergency Committees at Gros Islet, Dennery, Micoud, Vieux Fort, Choiseul, Soufriere, Canaries, Anse La Raye and Laborie).

The ODP Local Committees have much in common with the community based organisation which the project has established at Dennery and it is possible that a high local profile, as envisaged by the WMAFs will ensure the continuity of the WEMP programme. An example of the need for ODP and the WEMP to work together is the mapping of areas prone to landslides/flooding and the coastal areas most prone to storm surges.

¹ This includes a rough estimate for the sizeable flood-related damage to business inventories and personal belongings.

3.5 STAKEHOLDERS PERCEPTION

3.5.1 General

In determining the critical factors which must be taken into account during the planning process leading to a watershed management plan, it was necessary to obtain the views of a wide cross section of society. This was done by a reconnaissance survey targeted at the rural population, interviews with individuals from various institutions, both government and non government and a review of secondary literature.

In order to bring about the changes necessary for a transition to sound, and sustainable management of the island's resources, an analysis of constraints was necessary. The most significant of these are:

- People's perception of natural hazards;
- An interpretation of the current and future role of the banana industry;
- The need for diversification as a move away from banana dominance and towards crops more appropriate to their location.

3.5.2 Perception of Land Conservation and Drainage

Soil erosion and its consequence is a major problem in St. Lucia. Over exploitation of land resources coupled with unsustainable cropping systems give rise to erosion and degradation of agricultural land, which leads to increased costs, low production and an increase in flooding of valley bottom land.

Generally St. Lucians are aware of the dangers associated with torrential rainfall, but see deforestation as being the main cause. Few if any, see poor land-use practices as being contributory. The relationship between erosion on upper slopes and siltation and flooding in valley bottoms is equally not appreciated, although farmers in the latter area are very conscious of the effects of flooding.

The incidence of landslides was not generally related to heavy rain, except in areas where a history of landslides exists. Even in these areas, land-use, the construction of houses and roads and the clearing of large areas were not seen as problems.

More specifically, banana cultivation on steep slopes was not recognised as contributing to soil erosion, and farmers were not well aware of the loss of expensive fertiliser, occasioned by high run-off.

Most farmers understood the need for drainage but had little knowledge of how to set out drains. High cost was cited as the main reason for poor maintenance, and this led to disputes where blocked drain outlets caused problems on neighbouring farms. Most farmers saw the need to prevent the dumping of solid waste in rivers and streams. In summary:

- soil erosion on slopes is not seen as a problem;
- floods and landslides are characterised as being unavoidable;
- land use other than deforestation is not seen as a cause of excessive run-off.;
- farmers lack technical knowledge of soil conservation and drainage;
- farmers on the flood plains see government as the main culprit, for not maintaining drains and desilting rivers.

3.5.3 Constraints to Economic Transformation

Legislation and enforcement as a tool to induce changes in land use is not an option, except in the case of forest reserves and Crown Land, but it could be extended to cover areas of high risk

(landslide hazard) feeder road construction and the building of new houses. In the remaining steep land areas any attempt to force change in land use by legislation is socially unacceptable and practically unworkable, and current high unemployment in rural areas must also be borne in mind. It is clear that alternative employment opportunities does not offer any relief to hillside farmers.

Crop diversification offers one solution, and could be of benefit to the economy as a whole in spreading risk and to hillside farmers likely to be squeezed out of banana production. Some key constraints are worthy of examination:

- **Marketing** – The Reconnaissance Survey showed that farmers had no confidence in the marketing arrangements for alternative crops. Many stated that they would rather abandon their banana lands than invest in alternative crops. However, this situation could be reversed if reliable marketing arrangements were established and prices for produce acceptable. Despite the market intelligence provided by ADCU, this did not reach the farmers, and many extension staff denied any knowledge;
- **Technical Skills** – Many farmers only have experience of bananas which have dominated cropping for the last 20 years. On-farm demonstrations and figures on inputs and output costs of alternative crops are needed;
- **Preadial Larceny** – This is a serious problem in some areas and farmers are afforded no protection by the Praedial Larceny Act. In one area, a “neighbourhood watch” type scheme is in operation;
- **Belief in Banana** – Despite the increasingly obvious fact that profitability of bananas has fallen (and for some farmers will continue to do so) having lived with the crop for so long, farmers cannot believe that the crop will not return to its earlier profitable level;
- **Land Tenure** – Some 30% of all bananas, much of it on the steeper slopes, are grown on family land where the comparatively short rotation banana is acceptable whereas more permanent tree crops may not be. This is seen by many as a serious constraint, but some of the farmers interviewed did not necessarily agree;
- **Farmer Age** – This is seen by many as a constraint, but with the average age for male farmers estimated at 47 years, and lower for females, the situation in St. Lucia is similar to other Caribbean islands and cannot be regarded as abnormal. Perhaps of greater significance, is the reluctance of the younger generations to enter farming;
- **Credit** – Most farmers, male and female, have experience of credit of one sort or another and are willing to borrow, so long as they are confident that their investment will yield benefit. Investment in tree crops with 3-4 years costs accumulating before any returns start to flow in could be problematical. Formal credit is charged at 12% interest, but softer loans, from Credit Unions at 6% might be more appropriate.

3.6 LEGISLATION AND INSTITUTIONS

3.6.1 Legislation

As part of the project, a comprehensive review of all existing environmental legislation was undertaken with assistance from the Attorney General’s Office. In a number of cases there is a need to amend or draft new legislation and there is provision in the development plan to meet the costs of a lawyer experienced in drafting environmental legislation to review and where necessary up-date legislation in support of the normal legislative process (see Section 9.2.2).

Annex 11 details the many pieces of legislation reviewed by the project and a primary task at the start of the legal specialist's assignment would be to agree an order of priorities for the review/revision process. In the past, Consultants and others have identified weaknesses in existing environmental legislation and have spent considerable time and effort in drafting new laws, or in proposing suitable amendments to existing Acts or Statutory Instruments. There is a tendency for such legislation not to be "owned" by the institution responsible for implementation and in consequence little effort has been made to have the legislation adopted. The following Sections detail some of the areas where inadequacies are said to exist.

a) The Pesticides Control Act (7/75)

There is some concern that the present Act does not provide powers to control the movement, storage, and distribution of toxic chemicals. To this end the OECS Legal Unit prepared a Draft Pesticides and Chemical Control Act in 1994, as one of a series of "harmonised" laws which might be adopted throughout the region.

b) Proposed Coastal Zone Management Act

The Consultants working on the NW Coastal Zone Management Project state that there is a need for specific legislation and presumably take the view that amendments to the Fisheries Act of 1984 will not suffice.

A draft Coastal Zone Management Act (and Regulations) was prepared in January 1993 as part of an OECS/NRMU and GTZ project. This seeks to provide OECS countries with a legislative and regulatory basis for ensuring a sustainable use of resources within their coastal zones. The aim is to help states to adopt regulations without drastic alteration to their enabling legislation and if adopted would lead to the repeal of the Beach Protection Act and in so doing transfer responsibility for beach protection from MCWT&PU to MAFF&E

c) Proposed Water Resources Act and Selected Regulations

This draft legislation, prepared in January 1990 by a FAO consultant, was intended to supersede the Water and Sewerage Authority Act, 1984 and incorporate the major provisions of the Land Conservation and Improvement Bill, 1987 (now the Land Conservation and Improvement Act 10/92)

Whilst the proposed legislation never eventuated and was to an extent overtaken by events, it pointed out a number of deficiencies in both the WASA and LCB legislation including:

- how the LCB would be funded (no provision to raise drainage rates) and how it would gain access to Crown Land to offer in lieu of compensation;
- public rights in water (the right to investigate, use, control, protect, manage and administer the water of St Lucia).

d) The Wildlife Protection Act (9/80)

The Act does not afford protection for wild flora and there is a suggestion that the provisions of the Act may need to be enlarged to accommodate the obligations assumed by the GoSL under the CITES Convention. The Forestry Department stated that there are sufficient powers under the Forest Soil and Water Conservation (Amendment) Act of 1983 to protect wild flora and there may be little incentive to amend the Act.

e) Land Development (Interim Control) Act (8/71)

There is no requirement for environmental impact assessments (EIA) to accompany applications for significant land use and development, or that environmental considerations should be taken into account when the Development Control Authority (DCA) makes its decisions. Whilst EIAs are not required by statute, the DCA does routinely require EIA on "large development projects undertaken

by the private sector" but this does not comprise "an efficient, uniform, multi-disciplinary vetting process for all major development projects and plans whether public or private"

The Consultants engaged on the NW Coastal Zone Management Project suggest that the DCA should take responsibility for new Coastal Zone Management legislation in addition to the administration of the Land Development (Interim Control) Act. This proposal is contained in the Phase I Final Report dated January 1995 and should be reconsidered in the light of more recent events including the work of the Watershed and Environmental Management Project

f) Land Conservation and Improvement Act (10/92)

The legal specialist to review and if necessary revise the legislation and draft the Regulations.

(It has been suggested that Land & Water Conservation and Improvement Act is a better title for the legislation and that the controlling body should be a Land & Water Conservation Commission rather than the LCB)

g) Crown Lands Ordinance (Cap 108, 2/252)

The ordinance gives the Commissioner limited powers to control squatting and is said to be in need of revision.

h) The Animals (Diseases and Importation) Ordinance (CAP 41, 1/341)

Animal Health Regulations under the provisions of the Ordinance were drafted in 1993 and additional Animals (Diseases and Relocation) Regulations were drafted in 1996. At the end of 1996, these two sets of regulations, had not to reached the statute books.

i) The Parks and Beach Commission Act (4/83)

Until recently the Commission was a single person, but has been re-constituted to include representatives from the Ministry, Police, Tourist Industry, Forestry, Hotel and Tourism Association etc. A very recent development (November 1997) is the proposed formation of a National Conservation Authority which would take responsibility for this, or similar legislation if the Parks and Beach Commission Act is repealed.

j) Solid Waste Management Act (20/96)

There is provision to raise funds from haulage and tipping fees and from an environmental levy imposed on all visitors to St Lucia. This levy will be collected by the Air and Sea Ports Authority and paid over to the SWM Authority. A Manager has been appointed, but Regulations have not yet been formulated.

k) Disused Legislation

There is provision for repealing laws which have become "spent" and for removal from the statute books. The following laws are not used and are thus, appear to be "spent".

- Board of Agriculture Ordinance (CAP 24, 1/196)
- The Government Pasturage Lands Ordinance (CAP 212, 1/378)
- The Agricultural Small Tenancies Act (22/75)
- Timber Industry Development Board Ordinance (24/63)

l) Old Agricultural Industries

Legislation which applies to agricultural industries which are now defunct or struggling to survive and possibly in need of repeal:

- St Lucia Limes Association Ordinance (CAP 37, 1/307);
- Cotton Ordinance (CAP 34, 1/310);
- Coconut Industries Fund Ordinance (CAP 34, 1/297) and regulations of 1959.

The general impression is, that whilst legislative improvements are always possible, the existing legislative base is adequate, but there is a pressing need for co-operation and collaboration amongst the various agencies involved in the protection and improvement of the environment.

There is also an urgent need, at the national level, to recognise the cost of undesirable environmental practices. The lack of progress in some aspects of the project during 1997, gives the impression that there is limited interest in the environment at the political level. This impression may well be false and may simply indicate that the Government has other pressing problems with which to contend and that, in due course, the environment will occupy its rightful place in the decision making process.

3.6.2 Institutions

A comprehensive review was undertaken of all the institutions involved in the broad environmental field in St. Lucia (see Annex 11) including:

- government institutions answering to a number of Ministries;
- parastatal organisations such as WASA;
- regional organisations such as OECS and CEHI;
- charitable foundations such as CANARI;
- non-government organisations such as the St Lucia National Trust and WWF;
- community based organisations.

Special mention must be made of the Ministry of Finance, Planning, Information Services and the Public Service (MFPIS&PS), the Divisions/Departments in the Ministry of Agriculture Forests, Fisheries and the Environment and SLBGA which have a special role to play

a) Environmental Unit (MFPIS&PS)

The Environmental Unit in MFPIS&PS is responsible for policy issues in the fields of: Environment, Energy, Science and Technology. Amongst other duties, the Unit is required to act as the Secretariat for the National Environment Commission (NEC), which in turn should be St. Lucia's principal environmental authority.

The decision to establish the NEC was confirmed by Cabinet in March 1995 (Cabinet Conclusion 450 of 23/3/95) in response to a submission from the Ministry drawing attention to the perilous state of the environment following TSD. The broad functions of the NEC are as follows:

- to provide guidance and advice to Cabinet, parastatal and non-governmental organisations (NGOs) on environmental matters;
- to co-ordinate the inputs of Governmental and NGOs as well as private sector agencies/interests in the implementation of the NEAP;
- to mobilise financial and technical resources in support of environmental projects and activities, especially at the community level;
- to monitor and evaluate the implementation of the NEAP;
- to assist with the design and delivery of training programmes/workshops in environmental management and sustainable development;
- to organise and/or supervise applied research in accordance with the NEAP.

The World Bank requires its clientele to adopt NEAPs and with Bank assistance GoSL produced a draft plan in May 1994 and the Environmental Unit finally completed the NEAP early in 1997 for approval by Cabinet in May 1997, just before the change of Government

At the end of 1997, the National Environmental Commission, the organisation charged with overall responsibility for national environmental management had not been nominated and had yet to hold its first meeting.

b) Physical Planning Unit (MFPIS&PS)

The Physical Planning Unit (PPU) services the Direct Control Authority (DCA) with responsibility for the built environment and the Land Development (Interim Control) Act of 1971. The Unit includes a GIS Section which is well equipped with human / other resources and would need little additional assistance, in order to meet the demands of a future Watershed and Environmental Management Programme.

It appears difficult for the DCA to exercise much control outside the main settlements and enquiries in a village like Dennery, indicate that people build where they can find land and that in practice, the planning process tends to be extremely casual. Because of limited land, a significant percentage of houses might be in flood or landslide areas and the true position could only be ascertained by a detailed housing survey, along with the identification of alternative housing plots for those who ought to be relocated.

c) Agricultural Engineering Services Division (MAFF&E)

The Agricultural Engineering Services Division of the Agricultural Department is, or should be, the implementing agency for the Land Conservation and Improvement Act, however out of a total complement of 16 engineers and technicians only 8 posts were occupied at the end of 1997.

d) Agricultural Extension Division (MAFF&E)

A comparatively large staff resource which hardly impacts on watershed management at present, is the Extension Division of the Department of Agriculture which consists of a Chief Agricultural Extension Officer, and the following staff:

- 11 Co-ordinators (Subject Matter Specialists);
- 2 Produce Inspectors;
- 30 Extension Officers of various grades based in the 8 Regions;
- 8 Support staff.

Extension staff cover the eight Regions and are based at Union Agricultural Station.(# 1), Babonneau.(# 2), Dennery.(# 3), Micoud.(# 4), Beausejour.(# 5), Soufriere.(# 6), Roseau (# 7). and Bexon (# 8). Each Region is staffed by a Senior Agricultural Assistant (mostly diplomates) and two or three Agricultural Assistants. The latter are either diplomates or older experienced officers. The Division is responsible for all extension services, other than the banana crop.

e) Forestry Department (MAFF&E)

The Department is responsible for administering the Forest Soil and Water Conservation (Amendment) Act of 1983 and for the Wildlife Protection Act of 1980 and comprises eight units under the Chief Forest Officer (Protection and Patrol, Education and Information, Wildlife, Research, Nursery, Survey and Mapping, Crown Lands and Forest Operations). A number of the units are of special interest to the project including:

- the 5 Range Officers responsible for the areas of Forest Reserve which cover about 30% of the country;
- the 5 Extension Officers responsible for working with Community groups;
- the Education/Information Unit which includes Eco-tourism and provides publications and other material for use in the watershed management campaigns;
- the Protection and Wildlife Units.

The Forestry Department leads the country in conservation education, a programme which started in 1979 with a campaign to save the St Lucian parrot. It then extended campaigns into other areas such as forest, wetlands, bio-diversity protection and the recent River Conservation Project. A pleasing feature is the Department's genuine interest in conservation, the legacy of a former Chief Forest and Lands Officer.

f) St Lucia Banana Growers Association (SLBGA)

Established under the Act (6/67) and under the general jurisdiction of the Minister (MAFF&E), the SLBGA is charged with marketing and control of all bananas produced, has a responsibility to promote, finance and assist the industry and is the sole exporter. The nine person Management Board is made up of 6 members elected at the Annual SLBGA Conference of Delegates and 3 members nominated by GoSL.

The SLBGA's advisory service could have an important part to play in erosion control in banana lands, (at present the main contributor to soil loss on steep slopes). The Island is divided into five Regions (Northern, West Central, East Central, Eastern and Southern) with a Regional Manager and six or seven Technical Service Assistants in each Region

3.7 OTHER ENVIRONMENTAL INITIATIVES

3.7.1 Coastal Zone Management

The terms of reference, place an emphasis on Coastal Zone Management (CZM) and the need to protect the coastal environment. It is therefore important to define project responsibilities in this regard. The inter-relationship of CZM (or Integrated Coastal Zone Management ICZM) with Watershed Management is recognised and the project endorses the view that for small islands there is a need to adapt CZM principles to accommodate the holistic Island Systems Management (ISM) philosophy. Nevertheless the agencies responsible for Coastal Resource Management (CRM) and Watershed Management are different and provided there is co-operation and co-ordination at the policy level, it is not necessary to do more than briefly review the present CZM activities and plans.

a) The NW Coastal Zone Management Project

This CIDA funded project, was carried out by the Fisheries Department and Atria Engineering Consultants and covers the area from the south of Roseau beach to the top of Cap Estate. Phase I, the Pre-feasibility Study, took from late 1993 to January 1995 with a second phase due to start early in 1998. The project includes seven watersheds, one of which is Cul de Sac.

In preparation for Phase II of the project, the Fisheries Division has created a CZM Section and it appears likely that the project initiative will be translated into a permanent CRM institution.

b) Soufriere Marine Management Area (SMMA)

The SMMA covers the coastal area from just north of Choiseul Bay to Anse Mamin, north of Soufriere. This is largely a self-funded project, administered through the Fisheries Department with some external assistance. A recent contribution from France of FF1.5 million, will be spent on watershed management in the Soufriere area. The project involves a high degree of participatory management by the stakeholders and is a good example of both the success and the frustrations of this type of development.

c) Canaries and Anse La Raye Marine Management Area (CAMMA)

At the end of 1997, the Fisheries Department awaited Cabinet approval for the CAMMA which will "fill the gap" between SMMA and the NW Project Area. In due course a series of Marine Management Areas will probably encircle the Island and will relate to, or be influenced by, the equivalent Watershed Management Area.

3.8 THE CONSULTANTS APPROACH

3.8.1 General

In view of Government's weakness in controlling the environment, particularly cultivation in forest reserves, clearing of upper slopes to make way for bananas and uncontrolled building in many areas, the Consultants looked for a solution from an entirely different viewpoint. This essentially put the onus on the stakeholders through community participation and the BDDC Project Document had suggested such action.

People's participation and community initiatives are increasingly recognised as indispensable parts of sustainable management of natural resources. Experience suggests that the benefits of environmental management are more likely to be achieved when the ultimate clients are actively involved in designing and implementing the work necessary. In the St. Lucia context, the essential changes in land use and behavioural attitudes, can only be achieved with the consent and co-operation of the rural communities.

In Annex 9 The Main Socio-Economic Issues, an analysis of peoples understanding, attitudes and constraints to change pointed to a need to involve communities and proposed a number of solutions, which would lead to steady improvements in Watershed Management.

The following sections examine the role of community based organisations in implementing the watershed and environmental management plan.

3.8.2 The Need for Community Based Organisation (CBO)

Historically, community based organisations in St. Lucia go back a long way. Over the years changes have evolved, and many of the stronger COBs became non-governmental organisations (NGOs). The advent of grant funding brought about further changes, more formal structures and bureaucracy, but with it an ability to challenge the State, confronting its deficiencies and seeking backing for community initiatives.

With the demise of the local government system in 1980/81, came a weakening of community leadership and an increased dependency on Central Government. CBOs struggled to find a new role, although they still retained a limited capacity to address problems facing rural communities. They have tended to suffer from a lack of dynamic leadership and too limited a community base, and perhaps a failure to understand or analyse the scope of achievable objectives.

It is with an understanding of the history, strengths and weaknesses of CBOs that the Consultants have developed proposals for the active involvement of stakeholders through a Community Participation Programme (CPP) as being the road most likely to lead to successful watershed management.

The basic features of successful CBOs are:

- clear geographic focus;
- local management and control;
- a clear prioritised agenda;
- energetic leadership;
- self reliant funding.

Within the Phase 2 Trial Programme, (Annex 7) a Community Participation Programme, in the Dennery watershed was established. The monitoring and evaluation of this trial and its future replication throughout the islands watersheds, is an important component of the National Watershed and Environmental Management Plan put forward by the Consultants.

3.8.3 The Main Features of the Community Participation Programme

This section sets out the main features of the Community Participation Programme. For further detail reference should be made to Annex 10. The Community Participation Programme and Annex 11, Legislation and Institutions.

i) **The Institutional Setting** – This aspect is covered in detail, in Section 2.5, and is summarised here in the interest of continuity.

The Land Conservation and Improvement Act (1992) made provision for the establishment of the Land Conservation Board and local entities. It is within this legal framework that the proposed Watershed Management Action Forces (WMAF) will be formed, affording co-ordination of government departments and other interested institutions at both the central (LCB) and local (WMAF) levels.

The post of Community Participation Coordinator (CPC) would be created within the LCB to drive the process of WMAF formation. At the technical level WMAFs would be supported by a Technical Operations Team drawn from the staff of government ministries, their role being to assist the WMAF in adding technical dimension to the problem areas identified in their respective watersheds, and to aid the process of prioritisation.

ii) **Tasks and Responsibilities** – the main task of the WMAFs is to identify, prioritise and implement programmes, aimed primarily at the reduction and cessation of practices leading to environmental degradation. This will be effected through:

- education and training – to facilitate the necessary changes in attitude and behaviour towards the environment, a continuous effort in educating and training is indispensable, to transform watershed management from a highly expensive reactive emergency programme to a natural process deeply rooted in comprehension and personal responsibility of the individual towards the environment and the community at large. This would be co-ordinated by the CPC using the Technical Operations Team, and such external technical assistance as necessary;
- implementation – the WMAFs after initial surveys, would draw up and prioritise a master plan, which would then provide a source for detailed annual plans. The implementation of these plans would be the responsibility of the WMAF. Works would include small local initiatives, e.g. drain clearance during the pre rains period, and works requiring external funding through either the River Management Unit (RMU) of the LCB or for major works the MCWT&PU;

- monitoring – the very nature of the WMAFs with their broad base of local knowledge, put them in an ideal position to monitor their watersheds. They should be the first to notice problems with drainage, improper land use, landslide risk areas, inappropriate or illegal feeder road construction etc. Surveys completed soon after WMAF formation would provide a detailed baseline.

iii) **Authority of Enforcement** – without authority, the WMAFs are bound to fail, and will not be taken seriously. Their authority stems from the Land Conservation Board, established under the Land Conservation and Improvement Act (1992), which by delegating and defining responsibility at Action Force level, would allow for:

- implementation of works, resolving disputes and enforcing regulations;
- the generation of funds and the associated financial responsibility.

iv) **WMAF Formation** – During the formation process full account must be taken of local clubs and other organisations, and representatives of these together with influential local people and any locally based government staff should all be invited to the initial public meeting(s). Meetings would be organised by the CPC who would be supported by prospective Technical Operations Team (TOT) members. The basic objective would be to start the sensitisation exercise by explaining:

- the relation between people's attitude, environmental mis-management and respective consequences;
- to present the main ideas of the community participation programme;
- to highlight the need for community participation and formation of a WMAF;
- to explore the views of the community representatives regarding the formation of a WMAF for the watershed;
- to explore the view of the community on tasks, responsibilities and resources needed;
- to explore the possible composition of WMAF based on interest and enthusiasm shown by participants;
- to delineate the next steps towards establishment and empowerment of the WMAF.

This exercise leads to the adoption of the principle of forming a WMAF, the election of members (15/20 suggested) and office holders. Membership should include a broad cross section of local interests including women, and the importance of good leadership should be paramount. Membership would be on a voluntary basis and attract no payment.

v) **Technical Staff and Operations** – while overall supervision would be the responsibility of the LCB, at WMAF level the CPC would provide day to day assistance and advice, but being careful not to dictate the agenda. Technical support would be provided by a Technical Operations Team, comprising three officers drawn for LCB, Agricultural Extension, Forestry or other Department depending on the particular emphasis dictated by the individual watershed. The team's initial task, following surveys and the assembly of basic data, would be in assisting the WMAF to draw up a master plan, and from this, the first annual plan for implementation. The TOT would in addition supervise works, hire and fire labour and monitor and report to the WMAF.

The WMAF would meet at least monthly, meetings would be formal, have a pre-circulated agenda and be minuted. To maintain contact with the communities they serve, public meetings would be held at six monthly intervals when the WMAF would:

- present and/or discuss the annual work programme;
- present financial accounts;
- discuss important issues.

A reporting structure would be put in place as follows:

- WMAF - quarterly reports to Chief Engineer LCB with copies to the Chairman of the LCB;
- CPC - to WMAF as and when required and to Chief Engineer quarterly;
- TOT Supervisor - internally to WMAF as required and through CPC to Chief Engineer LCB.

vi) **Resource and Funding** – During the formation process, early consideration must be given to the provision of an office and basic office equipment for the WMAF. Siting is important as it must reflect the status of the WMAF in relation to other offices, and it must be large enough to accommodate WMAF staff, the TOT and visitors. Offices within existing government regional offices are quite acceptable, provided the WMAF retains a clear identity, and would have advantages of cost sharing and ease of liaison with departmental staff. The WMAF would also need access to facilities suitable for public meetings.

The cost of a programme based on the development of WMAFs for the whole island, would comprise several elements

- salary for the CPC;
- provision for travelling and subsistence;
- budget to cover sensitisation, advertising meetings, literature etc;
- provision of office facilities and basic office equipment;
- provision of teaching and training equipment;
- provision of essential tools and equipment;
- salaries for TOT, secretarial staff etc;
- running cost of office;
- cost of training including fees for external trainers;
- funds for minor works – local resources/fund raising;
- funds for medium works – budget within LCB;
- funds for major works – through MCWT&PU budget.

Notwithstanding external funding the WMAF must be allowed to retain its identity, base its programmes on broad community acceptance and set its own timetable for implementation of works. The pitfalls of top down planning must be resisted at all cost. Progressively each WMAF should seek a high degree of self financing through exploiting:

- local fund raising;
- assistance from 'soft' donors;
- drainage rates;
- water abstraction rates;
- fines.

Full details and cost estimates are included in Chapter 8.

Reporting structure would be put in place as follows:

- * WMAF
- * Chief Engineer (to report to Chief Engineer)
- * Chief Engineer (to report to Chief Engineer)
- * Chief Engineer (to report to Chief Engineer)
- * Chief Engineer (to report to Chief Engineer)
- * Chief Engineer (to report to Chief Engineer)
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During the formation process, early consideration must be given to the provision of an office and basic office equipment for the WMAF. Staffing is important as it must reflect the status of the WMAF in relation to other offices, and it must be large enough to accommodate WMAF staff, the TOT and visitors. Offices within existing government buildings are quite acceptable, provided the WMAF retains a clear identity, and would have advantages of cost sharing and ease of liaison with departmental staff. The WMAF would also need access to facilities suitable for public meetings.

The cost of a programme based on the development of WMAFs for the whole island would comprise the following elements:

- * salaries for the staff
- * provision for training and equipment
- * budget to cover maintenance, advertising, meetings, literature etc.
- * provision of office facilities and basic office equipment
- * provision of teaching and training equipment
- * provision of essential tools and equipment
- * salaries for TOT, essential staff etc.
- * running costs of office
- * cost of training including fees for external trainers
- * funds for minor works - local government and training
- * funds for minor works - budget within LCB
- * funds for major works - through WMAF budget

Overriding criteria for the WMAF must be allowed to retain its identity, have its own programme of local community awareness and set its own timetable for implementation of work. The details of day to day planning must be retained at all cost. Progressively more WMAFs should and a high degree of self financing through exploitation:

- * local fund raising
- * extension to other staff offices
- * development of
- * other opportunities
- * fees

Full financial and cost estimates are included in Chapter 3.

Chapter 4

4 ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

4.1 INTRODUCTION

St. Lucia's economy, as well as its marine and terrestrial ecosystems, are extremely sensitive to inadequate environmental management. This has become increasingly apparent over the last 20 years with the increase in banana cultivation, largely on excessively steep slopes and at the expense of forest and other perennial tree vegetation, and with catastrophic erosion, siltation and flooding being experienced during periods of high intensity rainfall. While the economy has become more dependent on banana monoculture, it has also become more dependent on tourism which is increasingly likely to be threatened by problems due to inadequate environmental and watershed management largely resulting from this marginal land cultivation. These problems are now appreciated by both Government and International donors and funding agencies, and a number of projects have been instigated. Current Environmental Projects underway in St Lucia include the following:

- the CIDA-funded NW Coastal Zone Management Project (investigating the Coastal Zone from Roseau Beach to Cap Estate);
- the Soufriere Marine Management Area (SMMA) , now with some French-funding (investigating the zone from Choiseul Bay to Anse Mamin);
- the recently completed BDDC-funded Project with CEHI concentrating on water quality and fresh-water aquatic ecology: (a preliminary draft report having been seen by the Consultants).
- the System of Parks and Protected Areas Project, under the St. Lucia National Trust, identifying further areas for nature protection, including Grande Anse National Park, Morne Fortune Historic Site, Praslin protected landscape, Pointe Sable National Park, and Anse La Liberte Project.
- Environmental Education Project, under the Department of Forestry.

In reviewing existing information and projects the Consultants have become increasingly aware that most of these have been focusing more on the symptoms, rather than on the sources of the environmental problems. Thus the all-important soil conservation problems have received little attention, while the studies in the marine and freshwater ecology fields have been well covered.

The long-list of environmental issues applying both internationally and specifically to St Lucia is given in **Table 4.1**, which also gives an approximate assessment of the relative importance of these issues in the St Lucian context. In the table the most important issues, i.e. those representing current environmental costs of more than EC\$10m/year, are denoted by three arrows; two arrow and one arrow indicators denote less important issues, assessed to be in the order of EC\$1-10m and EC\$0.1-1m respectively. The table, however, does not show inter-relationships between issues, e.g. marine siltation being caused by silt in rivers in turn produced by river bank scouring and soil erosion.

Table 4.2 highlights the specific physical issues and outlines possible solutions to these issues. Further detail on these issues is given in the following Sections.

4.2 LAND-RELATED ISSUES

4.2.1 Soil Erosion

Soil erosion is by far the most important single environmental problem facing the country, both in terms of current economic losses (losses of topsoil, nutrients, worsening of run-off and resulting flash-flooding, damage to infrastructure) and future threats to other activities (directly to tourism and fishing, and indirectly, through declining agricultural productivity and rural incomes, to the stability of the entire country).

TABLE 4.1: ST LUCIA: ENVIRONMENTAL ISSUES & RELATIVE IMPORTANCE

PHYSICAL LAND		BIOLOGICAL ISSUES		File:ENVISSUS.wk3	
Category	Issue	Relative Importance	Issue	Relative Importance	
PHYSICAL LAND	Soil Erosion	1 Surface Wash	Individuals	37 Rare & Endangered sp	
		2 Mass Movements(Landslides)	Communities & Habitat	38 Birds	
	Soil Degradation	3 Loss of Plant Nutrients		39 Freshwater fish, invertebrates	
		4 Nutrient Imbalances		40 Marine fish, invertebrates	
		5 Acidification		41 Terrestrial Wildlife	
		6 Pesticide Accumulation		42 Soil fauna	
		7 Adverse Pesticide Affects		43 Crop Pests	
		8 Soil Surface Exposure		44 Human Disease Vectors	
		9 Decreasing Soil Infiltration			
		10 Spoil Disposal			
		11 Soil Waterlogging			
		12 Salinity & Sodicity Increase			
		13 Inappropriate Agric.Land Use			
		14 Land Lost to Construction			
WATER	Landsurface/drains	15 Surface Run-off		45 Rainforest	
		16 Surface drainage		46 Lowland Seasonal Forest	
	Rivers	17 Sediment Load		47 Riverine Forest	
		18 River bank Erosion		48 Swamp vegetation	
	River Water Quality	19 Solid debris load		49 Mangrove Vegetation	
		20 Dry Season Flow		50 Monoculture problems	
	Groundwater	21 Flooding		51 Decreasing genetic resources	
		22 Nutrient Loads			
	Marine	23 Pesticide Loads			
		24 Groundwater Recharge			
CLIMATE	Microclimate changes	25 Groundwater Quality			
		26 Siltation			
	Microclimate changes	27 Nutrient loads			
		28 Pesticide Affects			
	Microclimate changes	29 Decreasing wind Protection			
		30 Increased temperature/evapotranspiration			
	ATMOSPHERE	Dust	31 Decreased dry season rainfall		
			32 Increased convective rainfall		
	ATMOSPHERE	Odour	33		
			34		
NOISE	Temporary	35			
		36			
NOISE	Permanent				
HUMAN ISSUES	SOCIAL	52 Population Growth			
		53 Demography			
	SOCIAL	54 Legal Settlement			
		55 Illegal Settlement			
	SOCIAL	56 Land Ownership/Security			
		57 Social Cohesion			
	SOCIAL	58 Social Attitude			
		59 Health			
	SOCIAL	60 Domestic water Supply			
ECONOMIC	ECONOMIC	61 Income			
		62 Employment			
		63 Land Value			
		64 Credit Availability			
LAND USE	LAND USE	65 Agricultural Land Use			
		66 Transport			
		67 Mining/Industry			
		68 Agro-industrial activity			
INSTITUTIONS	INSTITUTIONS	69 Activity & Effectiveness			
		70 Scenic Quality			
AESTHETIC	AESTHETIC				

Note Relative importance assessed in terms of annual financial losses represented by each issue: <<< massive costs, >EC\$10m/yr; << large costs, >\$1m/yr; sig.costs, >\$100k/yr.

TABLE 4.2: ST LUCIA: ENVIRONMENTAL PHYSICAL ISSUES, RELATIVE IMPORTANCE, AND POSSIBLE SOLUTIONS

GROUPING	SPECIFIC ISSUE	IMPORTANCE	POSSIBLE SOLUTIONS
Soil Erosion	1 Surface Wash	<<<	a)Major campaign to install trash lines & maintain trash cover in banana lands; Extension Service to be strengthened; b)Steepest lands (some >25, all >30deg) to be underplanted with perennial trees c)Steepest land (>35deg), and land above water intakes, to be acquired by govmt for forestry plantations.
	2 Mass Movements(Land slides)	<<<	a)Highest risk areas (>35deg, more concave) to be identified and planted to perennial trees b)Surface Drainage in high risk areas to be improved; c)Areas threatening infrastructure to have compulsory acquisition orders
	3 Loss of Plant Nutrients 4 Nutrient Imbalances 5 Acidification 6 Pesticide Accumulation 7 Adverse Pesticide Affects	<< << << << <<	a)Solutions 1 a,b,c to be implemented; b)Balanced nutrients to be applied to all crops. a)Study to be implemented covering macro & micro elements*; a)Soil testing programme to be implemented*; b)Lime to be applied to balance N - fertilizer additions a)Study to concentrate on potential hot spots(banana sheds etc) a)Break crops to be promoted of nematicide use; b)Research on biological control (nematode - trapping fungi) to be promoted; c)Alternate use of different nematicides; {reduce nematicide use} d)improve soil drainage Spoil to be used to improve shallow soil areas (small homegardens) [Flat alluvial areas, lowermost river valleys; problem with bananas -drains to ensure WT below 50cm] Small, localised problems only, particularly on Windward coast;
Land Suitability	13 Inappropriate Agric.Land Use 14 Land Lost to Construction	<<< <<	Promote perennial treecrops in steeper banana areas; don't grow seasonal crops Don't allow building in flat alluvial lands; Selective Land Zoning for Construction in shallow soil areas;
	15 Surface Run-off	<<<	a)Solutions 1 a,b,c to be implemented b)Attention to be focussed also on agric.drains, and drainage of farm tracks & paths; Farmers to be advised in design & layout of drains
Rivers	16 Surface drainage 17 Sediment Load 18 River bank Erosion	<<< <<< <<<	Solutions 1 a,b,c to be implemented (solution lies more in land upstream, less so in rivers) a)Maintenance of 20m river reserves (permanent trees); b)Planting of cover plants; c)Avoidance of River straightening d)Promotion of 1 a, b, c, above.
	19 Solid debris load 20 Dry Season Flow 21 Flooding	<<< <<< <<<	a)Better rubbish collection & public education; b)Farmers to clear debris from farm drains; Promote perennial tree cover over larger proportion of watershed a)Better upstream water management b)Grow dasheen & Terminalia arjuna in lowest areas
	22 Nutrient Loads	<	Unlikely to be major problem, except in some rivers in dry season - Monitor river nutrient contents (incl K, N, and P2O5) and BOD in Lower Roseau, Choc, Castries; control cultiv. above WASA intakes. Unlikely to be major problem in rivers, but needs study.
	23 Pesticide Loads 24 Groundwater Recharge 25 Groundwater Quality	<	
	26 Siltation	<<<	[A massive problem, but solutions lie upstream in better land management] Temporary solutions (vacuum cleaning of reefs etc) needs further study.
	27 Nutrient loads 28 Pesticide Affects	<<	[A problem in Rodney Bay Marina, and in Castries Harbour] Needs further study; particularly pesticide adsorbed onto colloidal material, deposited in sea.
CLIMATE	29 Decreasing wind Protection	<	Ridgetops require permanent treecover for > 100m width.

Note Relative importance assessed in terms of annual financial losses represented by each issue: <<< massive costs, >EC\$10m/yr; << large costs, >\$1m/yr; sig.costs, >\$100k/yr.

Analysis of the Erosion Problem must separate the two main groups of processes: surface wash and mass movements.

a) Surface Wash

Surface wash, comprising largely sheet and rill erosion, affects the soil surface and operates to a greater or lesser extent during every rain event. It is related to intensity and duration of rainfall (erosivity factor) and permeability and structural stability of soil (erodibility factor), as well as ground cover and presence of mulch, steepness of slope, and length of slope. It is a great problem to agriculture in that it selectively removes the uppermost part of the soil surface: which contains the highest proportion of fertilizer and added nutrients.

Rates of surface wash erosion measured in humid tropical environments have varied from a few kg/ha/year to in excess of 500 tonnes / ha/year. Generally a rate in the order of 15 tonnes / ha/ year is considered sustainable: this is equivalent to 1mm depth of soil, which is the rate at which the soil profile increases in depth due to weathering and the other soil-forming processes.

In the case of surface wash, maintenance of ground cover, both vegetation cover and trash cover, is the most important factor in reducing erosion that can be easily implemented by the farmer. (Trials on maintaining ground cover with banana trash in sloping smallholder banana fields are reported in Annex 7.) The Consultants consider that widespread banning of banana cultivation on steep slopes would not be enforceable in the St. Lucian context. There is an additional danger that bans on bananas would lead the land to be cultivated by far more damaging crops, for example taro or seasonal vegetables. The presence of trash has been demonstrated to have a marked beneficial effect on soil infiltration rates, as well as having positive benefits in several other areas (soil surface protection against raindrop impact, increase in structural stability, recycling nutrients, keeping soil surfaces cool, improving the rooting environment). A major campaign to install trash lines and maintain trash cover in banana lands thus needs to be instigated, particularly on the steeper banana lands (i.e. with slopes of >25 degrees).

Land of over 30 degree slopes also needs to be targeted for underplanting with perennial trees, with a view to replacing the bananas completely by these trees. For banana land of between 20 and 30 degrees, partial replacement of bananas with rows of trees planted on the contour would be beneficial (See Annex 5 for Possibilities for Alternative Cropping). Both programmes need the active support of the Extension Services for technical assistance in setting out the conservation measures.

b) Mass Movements

Unlike surface wash, mass movements affect only relatively small areas (commonly 10-30m wide) but to much greater depth (commonly 3-8m). They tend to occur only infrequently, during periods of exceptional rainfall. Risk of mass movements is related to several factors, including:

- rainfall intensity level;
- antecedent rainfall and hence drainage conditions;
- slope gradient, especially in the vicinity of the initial movement area;
- vegetation type and cover, particularly rooting system density and depth;
- location of possible spring lines;
- concavity of the landform (sites of influx of water);
- soil type, especially in relation to infiltration capacity and soil depth;
- angle and direction of dip of the underlying rock strata;
- wind direction, wind speed, and level of 'gustiness';
- earth tremor activity;
- human interventions (soil removal, tree felling, road construction, house building).

Mass movements occur naturally irrespective of any human activity, and represent a natural process by which highly weathered (nutrient depleted) material is removed from the rooting zone of forest or other vegetation. Observations after TSD in 12 priority watersheds on 400 mass movement features revealed that 90% occurred in the uppermost-i.e. steepest- parts of the watershed, but many of these were under natural forest vegetation (mostly in areas with slopes of over 45 degrees as was further confirmed in the recent helicopter SFAP survey.) However, in removing forest vegetation, particularly on sites where the above conditions also hold, the risk of landslide occurrence increases markedly due to removal or decay of deep tap roots and an interlocked network of surface roots. Even after replanting of these sites to trees, there will still be a high risk of mass movements for many years, until the original rooting depth and density is re-achieved.

Figure 4.1A shows the distribution and type of mass movements across the island immediately after TSD. The estimated susceptibility of different areas to mass movements is given in **Figure 4.1B**. As an interesting comparison, **Figure 4.2** is a preliminary map showing areas of steep slopes, reflected here as dark areas where contour lines are very close together. (Some problems of displacement are evident with this map in the coastal areas, but displacements in the important upper watershed areas are minimal.)

For mass movements (landslides) the highest risk areas need to be identified and planted to perennial trees, and the complete banning of felling of existing perennial trees needs to be enforced for these areas. Essentially, high risk areas are those above 35 degree slope and possessing a more concave topography. Where these areas are above or below existing infrastructure and settlement, they should have the highest priority. The Cul de Sac Valley shows the greatest density of this land, and is thus an ideal test watershed for this activity. Some complete banning of cultivation is advocated in the worst cases: these areas should be acquired by government and planted to forestry trees.

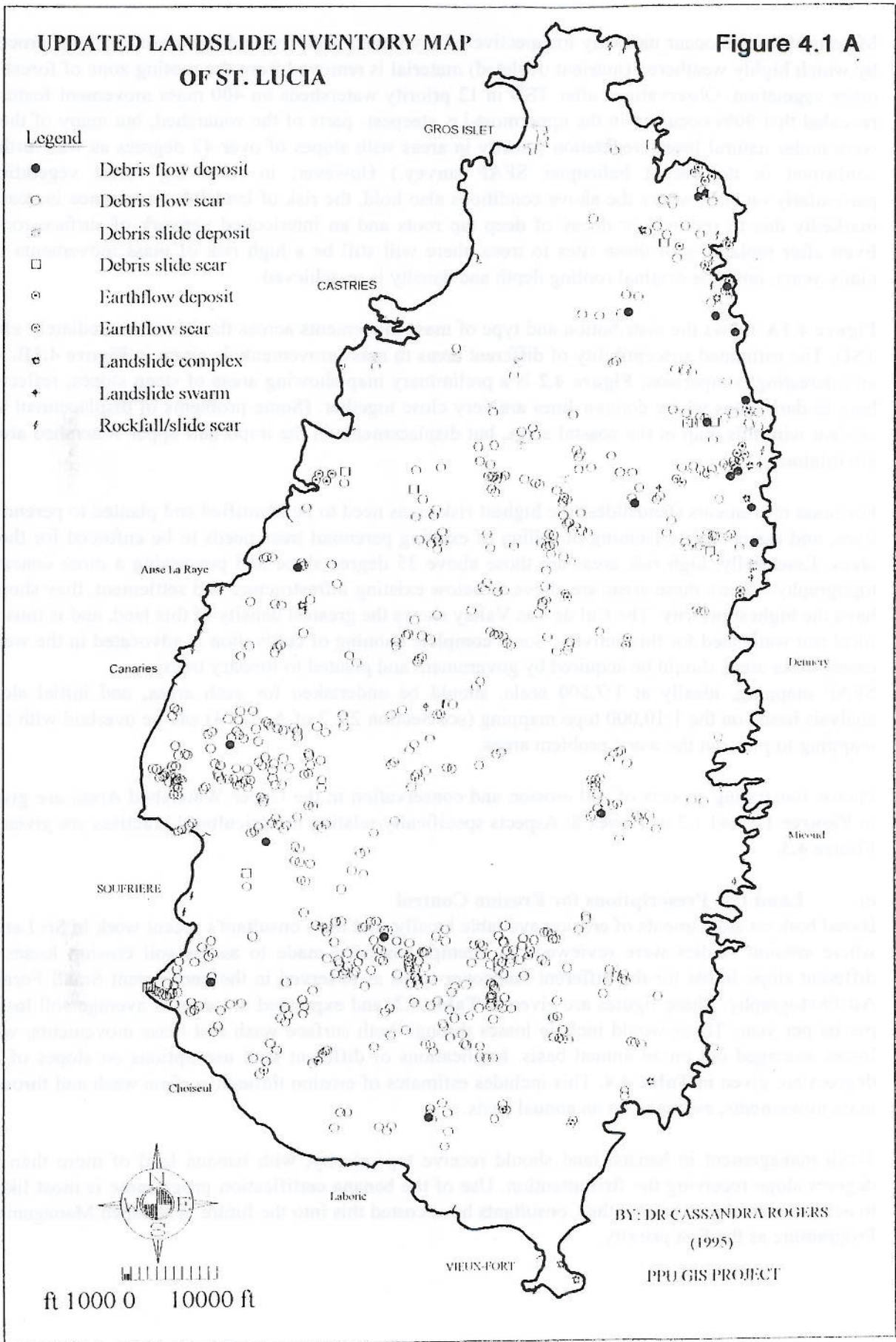
SFAP mapping, ideally at 1:7,500 scale, should be undertaken for such areas, and initial slope analysis based on the 1:10,000 topo mapping (see Section 2.2.2 of Annex 4) can be overlaid with this mapping to pick out the worst problem areas.

Photos illustrating aspects of soil erosion and conservation in the Upper Watershed Areas are given in **Figures 1.1** and **1.2** of Annex 8. Aspects specifically relating to agricultural practises are given in **Figure 4.3**.

c) Land Use Prescriptions for Erosion Control

Based both on assessments of erosion available locally, and the Consultant's recent work in Sri Lanka where erosion studies were reviewed, an attempt has been made to assess soil erosion losses at different slope limits for the different landcover types as observed in the very recent Small Format Air Photography. These figures are given in **Table 4.3**, and expressed in terms of average soil losses per ha per year. These would include losses through both surface wash and mass movements, with losses averaged out on an annual basis. Implications of different land use options on slopes of 30 degrees are given in **Table 4.4**. This includes estimates of erosion through surface wash and through mass movements, averaged on an annual basis.

Trash management in banana land should receive top priority, with banana land of more than 25 degrees slope receiving the first attention. Use of the banana certification programme is most likely to achieve this objective, and the Consultants have costed this into the future Watershed Management Programme as the first priority.

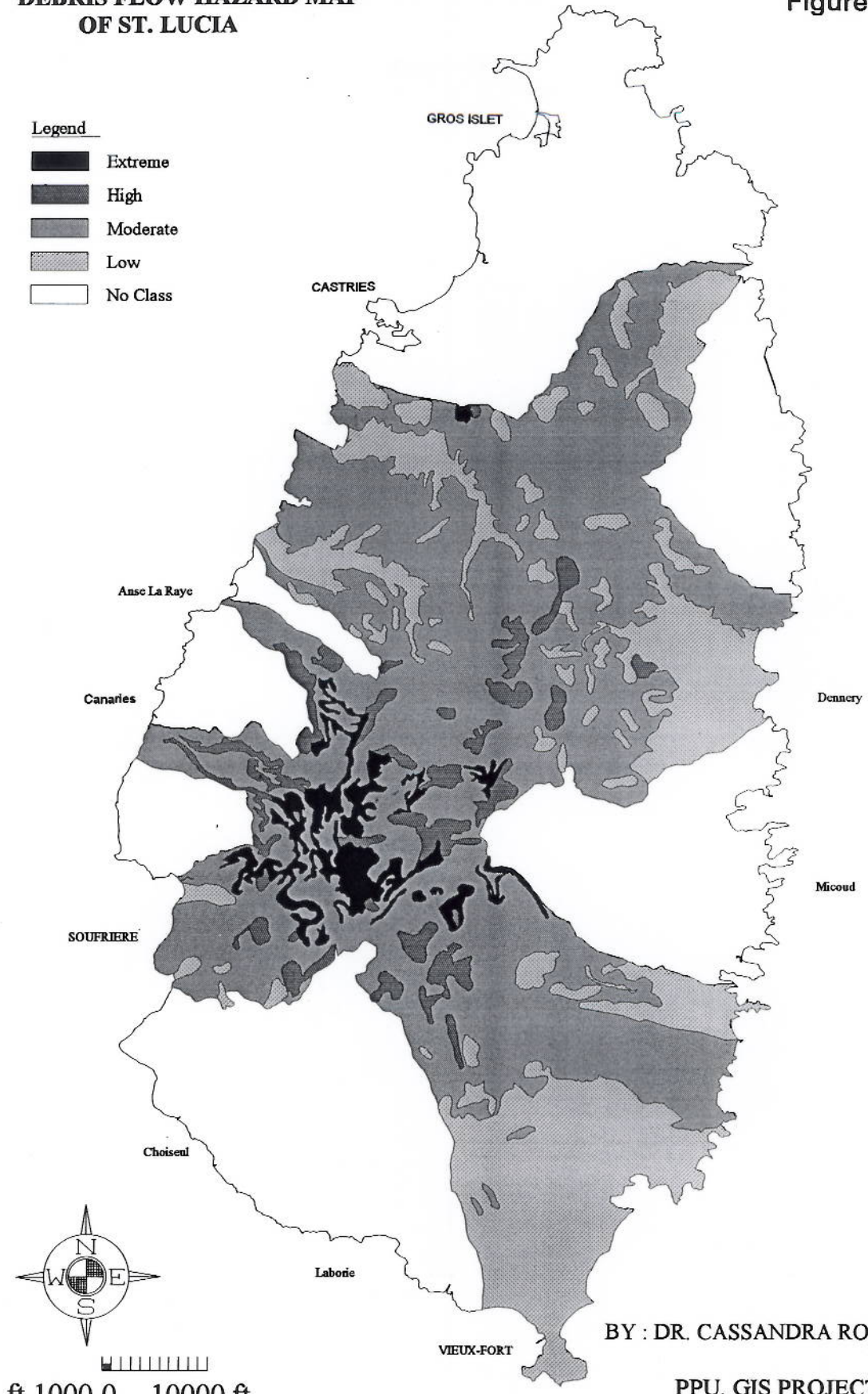


**DEBRIS FLOW HAZARD MAP
OF ST. LUCIA**

Figure 4.1 B

Legend

-  Extreme
-  High
-  Moderate
-  Low
-  No Class



BY : DR. CASSANDRA ROGERS

PPU, GIS PROJECT



CAPTIONS FOR PHOTOTGRAPHS

FIG 4.3. SOIL EROSION AND CONSERVATION: AGRICULTURAL PRACTISES

T left	<p>Establishment of Trash Lines in banana fields. These trash lines will retain any eroded soil on the slope. Experiment set up by Mr Martin Satney in 1996 on the land of Mr Descarte in the Micoud area. Note the use of the M-frame to position the stakes on the contour. Our trials covered trash lines and trash cover, but showed that shortage of suitable nearby material for stakes was a problem. Glyricidia would be the ideal material, but nurseries and strip plantings should be set up in all areas to supply stakes. Loppings from green sproutings from these stakes would be an excellent green manure & mulch material.</p>
T right	<p>Misuse of land on very steep slopes: recent clearing for annual crop cultivation in the Upper Soufriere Watershed. There is an urgent need to impose slope limits for such cultivation, as soil losses could easily be as high as 500 t/ha/year on steep land. Publicity and education is slowly getting over the message that such cases of gross misuse of land are unacceptable.</p>
B left	<p>Slumping due to scouring along river bank affecting good agricultural land, right bank of Roseau River. However, cost of gabion mattresses and rip-rap would be much too high in relation to any agricultural benefits achieved here by protection. Biological measures including grass planting on banks, and tree planting as a double row along top of bank would be recommended. Mangoes, breadfruit, coconuts, avocados, bamboo, teak (drier areas, good drainage-as here), mahogany (shade required) would be suitable.</p>
B right	<p>Cultivation of taro on landslide / slump material produced by Tropical Storm Debbie in 1994. Material from this slump crashed into the house at the left, killing a child in the front bedroom. Dasheen grows well in wet soil produced by slumping, but is a problem in that the crop is cultivated on an annual basis, exposing the soil surface to further erosion. Permanent tree cover in these areas is an urgent necessity.</p>

As a second priority, some slope limits should be placed on different types of cultivation. In the St Lucian context, and on existing cultivated land, the Consultants would suggest limits should initially be placed as follows:

- Annual/Seasonal Cultivation (cultivation on contour) 10degrees
- Monocropping Bananas (good trash management) 20degrees
- Bananas with treecrops, aligned on the contour (good trash management) 30degrees
- Treecrops, full cover, (again with trash management) 35degrees
- Long-cycle Forest Plantations (selective felling) 40degrees
- Conservation Forestry no limit.

The Consultants consider that it is important that precise figures be stipulated, as these can readily be verified in the worst cases of misuse by use of a simple clinometer. Some countries, (St Kitts, Malaysia) have formal slope limits stipulated in land use legislation; others (Sri Lanka, Indonesia) have limits stipulated in guidelines on land use adopted by government institutions, and followed closely by any internationally-funded project.

There is a strong case for setting up a Land Bank in the country in order to reallocate unused or grossly under-utilised land to those who are either landless, or possessing and cultivating land which is too steep or otherwise unsuitable for such uses. In the course of their work, the Consultants observed very many cases of both categories.

4.2.2 Soil Degradation

Soil erosion is the largest process of soil degradation. However, there are other processes which must also be considered. These include the following:

a) Loss of Plant Nutrients and Nutrient Imbalances

WINBAN estimate that 30% of nutrients applied to sloping land are lost through surface wash processes. Where concave colluvial footslopes exist below sloping areas, bananas are observed to be showing much better growth than in upslope areas, demonstrating the degree of nutrient redistribution. Farmers can compensate for this by applying more fertiliser to sloping areas than to footslope areas. Secondly, by carrying trash from the footslope areas and spreading this on the slopes (currently being practised in the field trials) they are improving the fertility and physical status of the sloping land. However, in most cases nutrients once mobilised will end up in the rivers where they may present a problem to the fauna and flora as well as being a loss to the farmer.

Efficiency of fertiliser application can be considerably increased by frequent small applications, and above all by good trash management, particularly installation of trash lines. Tied contour drains will also retain nutrient rich topsoil on slopes. Sub-surface fertilizer injection has been considered by WINBAN and this urgently needs further investigation, particularly for highly sloping land. Further development of the injector tool, and fertiliser efficiency trials on sloping land, should be carried out.

Removal of plant nutrients also takes place with the removal and sale of the crop, and these nutrients must be compensated for. Universal use of high-K banana fertiliser is not ideal: for many crops there is a need to change composition from a more evenly balanced NPK mixture initially, to a high-K NPK mixture when the treecrop gets to the bearing stage. Some crops (cloves, citrus) require a higher Mg:K ratio, and some are much more sensitive to low pH or high exchangeable Al levels. Higher P fertilisers are required for some crops (breadfruit, jakfruit, tomatoes, peppers), and to compensate for anion fixing soils (e.g. the allophanoid soils in St Lucia).

The current nutrient status of St Lucian agricultural soils needs to be studied, as the heavy use of high-K banana fertilizer may have led to severe nutrient imbalances in some cases. This becomes

even more important when crop diversification is considered, as many alternative crops require quite different N:P:K ratios to bananas.

Rational use of fertiliser, at frequent and small applications, and at the recommended levels, will enable complete crop canopies to be achieved quickly, and will have a net overall effect of reducing the rate of erosion. The Consultants have found little evidence of fertiliser overuse. The high-K nature of the fertiliser has little effect on aquatic life, potassium being the most benign of the major nutrients in terms of inducing algal growth, particularly in marine environments where the element occurs naturally in large quantities.

b) Soil Acidification

Heavy use of fertilisers over the last 20-30 years for banana cultivation has led to large falls in soil pH, with average values for most soils in the prime banana agro-ecological zones having fallen from about 5.8 as reported by Stark et al in 1966, to current values in the range 3.8-4.8 (Harris, 1995). pH(H₂O) values of 7 of the 8 composite samples taken in the agricultural trials were also in the range 4.6-5.0. Acidifying affects of heavy fertilizer applications have been the major cause of this marked fall in pH.

Although bananas are tolerant of fairly low pH values, calcium deficiencies have been shown to exist, and marked responses have been observed to lime applications both in St Lucia, and in other islands. Recommended liming rates (WINBAN) are 2 tonnes / ha at planting, with further applications of 500g / mat every 2 years. Harris (1995) recommends a ratio of 3:1 be maintained for NPK fertiliser:lime applications so that soil acidity problems are not worsened. On this basis, the island is using only 2% of lime requirement, which is a major cause for concern.

For most crops of the humid tropics, some tolerance exists to high acidity, and liming to pH values over 5.7, (or exchangeable aluminium saturation percentages of under 40%) are not advocated. However, pH(H₂O) values of less than 5.2, or aluminium saturation percentages of more than 65%, should be corrected with lime applications for all but the most acid-tolerant crops (e.g. tea, rubber, cinnamon). Some crops, notably cocoa, require higher pH soils, with values of 6-6.5 being ideal.

Lime is even more essential for earthworm activity, and thus areas treated with lime are likely to show higher infiltration rates, and higher structural stability. (This is currently under investigation with the soil conservation trials). Thus increased lime application will probably lead to reduced run-off and erosion.

Cost of lime (\$22.50 per 50kg bag) is a major disincentive for farmers, with this high cost being related to the low volumes traded. Purchase of larger quantities of lime in bulk, or development of local sources, should be investigated, as local agriculture should be applying 5,000 -6,000 tons / year. Imported dolomitic lime could be a major source of magnesium, which would be considerably cheaper than the magnesium included in the existing NPK fertiliser mixture, which is in the form of kieserite (MgCl₂). Agricultural lime for treecrop use in the tropics should be in the form of the cheaper carbonates (i.e. fine ground limestone) rather than burnt lime which is much more soluble and more expensive.

c) Pesticide and Herbicide Issues

Monitoring work undertaken by CEHI has shown only one measurement of detectable pesticide residues in river water from upper watershed areas (B.Lloyd, pers comm). It would thus appear that pesticide contamination of river water is not a major current problem, although it deserves further monitoring. The banning of cultivation above water intake points is essential because of the high potential use of pesticides in the cultivated areas, and particularly because of possibilities for accidental spillage which could be catastrophic.

The major pesticide use for banana cultivation is on nematicides, with alternate use of carbamates and organophosphorus compounds being recommended. Actual usage of these chemicals is only 60% of the recommended rates (Harris, 1995), with the consequence that blow-downs and other crop losses are much higher than they should be. Nematicides tend to be applied only in the immediate vicinity of the banana mat, leaving most of the area untreated. However, nematicides are of environmental concern because of the damage they cause to other soil fauna, notably earthworms. Under-use of nematicides thus would have a beneficial effect on earthworm populations, and thence soil infiltration rates. Nematode control by biological agents (e.g. nematode trapping fungi) is a possibility for future research activity. Another is the use of break crops (e.g. pineapples, *Brachiaria* grass as is used in the French islands, or arrowroot in St. Vincent) for a period of one year or more. After the break crop nematicides do not have to be applied for another two years. However, application of this method to St Lucia would be limited to the flatter lands.

Hot spots in pesticide contamination are likely to occur around banana sheds where fungicide is used. Contamination of the surrounding area by this and other chemicals would appear probable. In many cases discarded chemical containers litter the vicinity of these sheds.

WIBDECO and the SLBGA recognise the problems that pesticides have caused and the greater threat that they may pose in the future. The 'Certified Growers Programme' has a check-list of criteria, including 5 essential criteria, each of which has to be met for certification. Two of these comprise the use of chemicals, and the disposal of any waste. Charcoal pits have to be installed near the respective packing sheds for the disposal of any waste chemical, notably fungicide solution used for soaking the fruit prior to packing. Diothene sheeting and other non-biodegradable waste also has to be disposed of carefully: WIBDECO advocate on-farm burning of these waste materials by the farmer himself.

WIBDECO have recently introduced a draft 'Code of Practice for Banana Producers in the Windward Islands' which covers all areas (including banana plantation development, soil management, field practices, pesticide management, Sigatoka control, packing houses, waste management, labour practices, worker health/ training, and integrated crop management policy review). Accompanying this document is a more specific draft document: 'Guidelines for Pesticides Use and Waste Management for Banana Producers in the Windward Islands'. It is likely that with certification now proceeding rapidly (60 farms per week being vetted, and approximately 30 farms certified), that the certified farmers will follow recommended practices on use of pesticides and disposal of waste.

Farmers not certified will increasingly comprise the hillside farmers on the most marginal land. These farmers will face increasing pressure to diversify out of bananas. However, in mixing their bananas with other crops they will be forced to adopt hand-spraying for leafspot control, rather than the cheaper aerial spraying. A further reason for hand spraying of bananas when mixed with some crops (notably nutmegs) is the sensitivity of the alternative crop to leafspot spray. Although this does not apply for the common alternative treecrops grown in St Lucia, it will have to be watched in any introduced crop.

In the long term research on biological control mechanisms is likely to pay dividends. Two areas already mentioned are:

- nematode trapping fungi;
- shade-tolerant cover crops with nematode-detering root exudates.

Research on biological control would be beyond the immediate scope of local resources, but would be the ideal subject for University research, and/or for research funded by external projects.

d) Soil Surface Exposure and Decreasing Soil Infiltration

This is a major contributory factor to the soil erosion problem, and was addressed directly in the soil conservation and erosion control trials reported in Annex 7. Maintenance of an even trash cover, establishment of trash lines, tolerance of some weed cover, promotion of earthworm activity, and improved soil drainage will all lead to improved soil structure and increased infiltration.

e) Spoil disposal

Landslide materials, accumulated silt on roads and in infilled river-beds has to be disposed of, and in most cases this has been done on the nearest relatively flat land, with relatively little thought of how the spoil material may be used to maximum effect. Cases of inappropriate disposal of spoil material were seen in the Phase 1 works (see Annex 8).

Two major uses of spoil material would be for building sand or aggregate, and as rootable material for plants.

Building sand and stone for aggregate is currently extracted from many river beds, mainly on an ad-hoc basis. With the current high rates of soil erosion, much material is tending to accumulate in river beds, and in certain sections much of this is of the correct size fraction for use as building sand, although lenses of silt or finer material may also be present. Extraction of such material, if properly regulated, may actually be beneficial in allowing capacity of the river channel to be maintained. Care has to be exercised in moving excavators and loaders into and out of the river bed, so that banks with their stabilising vegetation are not damaged. Rapid rates of extraction may have an adverse effect on the balance of sand accumulation and removals on beaches, so this needs to be monitored carefully.

In most major watersheds, areas adjacent to the lower alluvial floodplains have large proportions of shallow soils, and these would benefit considerably by having an increased depth of rootable material. Finer-textured materials deposited in the lowest sections of the river bed are also of greatest value as rootable materials, having higher available water holding capacities (AWCs) and CECs than the more sandy materials deposited in higher sections. Thus spoil should be targeted for these shallow soil areas, particularly those being earmarked for homegardens. The outer area of Dennerly town is a clear example of this (see Figure 4.4, bottom right-hand photo). Soil profiles here are commonly only 20-30cm deep, and vegetation thus dries out very quickly during dry periods. A further 20-30cm of rootable material would benefit such areas enormously. Ideally old topsoil material should be mixed with the new spoil material, and additional fertiliser nutrients applied in the first year.

f) Soil Waterlogging

High watertables in the alluvial floodplain areas represent the greatest limitation to high banana yields in most years: flooding will represent a catastrophic limitation in perhaps 1 year in 10. The drainage problem is aggravated by infilling of the drains by silt brought down by frequent floods. Maintenance of water tables (WTs) below 90cm are required for bananas, particularly in drier areas, but many areas show WTs within 50cm. All of the drainage installed is by open, usually steep-sided drains.

For the lowermost courses of the major rivers, elevation differences between the ground surface and the river bed are too low for drains to be installed to the optimum depth - say 1.0-1.4m. Drain depth tends to decrease in the marginal banana land to the limit where drainability is too problematic, and hydromorphic grasses or wetland forest become the dominant vegetation types.

Construction of open drains in the very poorly-structured alluvial silt materials also presents problems in that the sides of the drains are susceptible to local scouring and slumping during periods of heavy rainfall. Possibilities of stabilisation of drain sides with trash lines - say placing the lines

within 40cm of the drain bottoms - or with shade-tolerant cover crops need to be investigated. Deepening of the main drainage lines in the area to the North of Bexon Office has recently been undertaken, with some depths exceeding 3m. Bad slumping along the sides of these drains was noticed here.

4.3 WATER RESOURCES MANAGEMENT

4.3.1 Flood Management and River Engineering

a) Flood Hydrology of Recent Events

Flooding Management and River Engineering requires the knowledge of what causes flooding in different localities, how flooding can be predicted and its impact minimised.

Lessons can be learnt from the events of TSD and of October 1996. The meteorological factors related to the two events and the responses of the watersheds to the intense rainfalls need to be appreciated. These factors not only relate to flood risk but are also important aspects of landslide hazard assessments.

The catchments of St. Lucia respond quickly to rainfall events and a peak flood can be over in a matter of hours. Therefore rainfall characteristics over a period of 2 to 10 hours during a storm event are vitally important in the estimation of the severity of an event. Unfortunately, few attempts have been made to estimate flood peaks whilst little information has existed with regard to the rainfall intensity-duration characteristics across the Island.

Flooding in St Lucia is almost totally related to short duration high intensity rainfalls. If preceded by a period of at least average rainfall, such antecedent moisture conditions can aggravate the flooding situation. In some circumstances and locations, the flooding can be caused by inadequate drainage channel capacities or more commonly inadequate cross drainage capacities.

A full description of the flooding conditions as related to St. Lucia is presented in Annex 3 and the associated appendices.

Little information exists to date on the rainfall intensities which have been experienced on the Island during severe flooding events. Analyses during the course of this project have demonstrated the importance of high rainfall intensities over a period of about 4 to 6 hours duration in terms of flood flow generation and landslide propensity. Intensities peaking in excess of 70 mm/hr have been recorded both during TSD and the event of October 1996 (See Annex 2, Appendix B and C for more details). Rainfall intensities cannot be readily related to daily rainfall totals, the basis for the majority of the climatological data base within St Lucia.

Apart from the lack of short duration rainfall information across the Island, little information exists with regard to flood discharges. Flood events in the past have often not been recorded because the equipment did not operate since it was damaged or over-topped. No crest level gauges have been in place to record peak water levels. There has been a major focus on directing the climatological (esp. rainfall) and hydrometric records on agronomic / agricultural information needs rather than flood management information. Few peak flood discharge current meterings have been undertaken although problems do exist with regard to the high debris loads during current metering because of equipment damage and snaring.



CAPTIONS FOR PHOTOGRAPHS

FIG4.4 PROBLEMS IN THE LOWER WATERSHED AND COASTAL ZONE.

T left	<p>NW Cul de Sac. Note major area used for oil terminal; remaining floodplain zoned for industrial/commercial expansion; floodplain too narrowly confined by road project and embankment; straightening and canalisation of lower river prevents silt deposition in lower floodplain worsening silt deposition in sea; road project currently tipping spoil into sea; silt stirred up by shipping; Ciceron rubbish dump encroaching on wetland forest; bad erosion of the beach (12 people are currently mining beach sand for construction; expansion of Castries into the surrounding areas. (SFAP photo C6 24)</p>
T right	<p>Cul de Sac: extreme NW. A complex of environmental problems seen here: the new road project producing massive siltation; silt accumulation in bay; severe beach erosion due to sand mining; breaching of sand bar across river mouth leading to more silt in sea and drainage of wetland forest; problems of town rubbish tip-further degradation of wetland forest; unplanned periurban expansion & encroachment; smallholder cultivation exposing bare soil in recently settled areas.(SFAP photo 8-28)</p>
B left	<p>NW Cul de Sac. Area zoned for industrial & commercial expansion but problems are evident: river straightened & canalised and cut off from floodplain; floodplain v. confined by new road project & opposite embankment-also by bridge & W.coast road; massive encroachment by construction onto good agric.land; flood-risk to buildings is evident. Further problem is that unconsolidated alluvial materials require very expensive foundations and/or are not suitable for multi-storey building. (SFAP photo 8-25).</p>
B right	<p>Dennerly. Mouth of river and town. Note shallow soil areas on convex ridges which can be zoned for building if not too steep-spoil from rivers can be used to increase soil depth in homegardens in such areas. Only moderate siltation in Dennerly Bay; natural formation of sand bar at mouth of river leading to silt being trapped in lowermost part of river; cultivation to annual crops in alluvial floodplain beyond main road- use of dry season river water for irrigation needs regulation; Dennerly Town would benefit from beautification and tree-planting scheme. (SFAP photo C3-19).</p>

TABLE 4.8 ESTIMATED PEAK FLOWS DURING TROPICAL STORM DEBBIE.

Location of Flow Estimate		Estimated Q_p (m^3/s)				
River	Site	Area (km^2)	Rational Method ¹	Rational Method ²	Manning Method ¹	Avg.
Cul-de-Sac	nr. Outfall	40	792.3		819.5	805.9
Cul-de-Sac	Ferrand's Bridge	30		525.4		525.4
Cul-de-Sac	Bexon	9.4	182.1	164.6	225.5	190.7
Dennerly	Upper catchment	6.93	172.6		243.2 ³	207.9
Dennerly	Upper catchment	12.1	234.4		209.7	222.1
Roseau	Middle catchment	22.8	441.6		472.6	457.1
Roseau	Dam	15.2				270 ⁴

Notes:

1. As applied by Rodriguez (1994)
2. As applied by Eernisse (1996)
3. Water level believed to have been significantly raised by channel blockage, resulting in a probable over-estimate of the flow.
4. Methodology applied by Stanley-Klohn Leonoff not specified. Estimated maximum discharge from dam in the range of 260-375 m^3/s with peak flood to dam prior to breaching in the range of 240-290 m^3/s .

- **October 1996**

Further serious floods occurred in late October 1996. Although some areas experienced very high rainfall intensities, it was generally a less severe event. Perhaps it was fortunate that much debris and landslide hazard areas had been 'actioned' by TSD thus reducing in some respects the impact of the October 1996 event. However, in some areas, flooding is believed to have been aggravated by the increases in bed levels which occurred in some river reaches brought about by the deposition of heavy bed loads by TSD. Some channels were 'desilted' during Phase 1 of WEMP but this will only have provided localised benefits in some of the worst areas.

Rainfall measurement during the events up to and during October 26th was significantly improved by the fielding of new rainfall recorders and data logging systems as part of the WEMP Project. Many of the planned new recorders had been installed and provided excellent short duration rainfall intensities during the events. Detailed analyses are presented in Annex 3. The isohyets for the 2 day rainfall totals, October 25th and 26th are given in Figure 4.5 and indicates the catchments with the high rainfall depths.

TABLE 4.9 MAXIMUM RECORDED RAINFALL INTENSITIES FOR 26 OCTOBER 1996

Rainfall Station	Maximum Intensities (mm/hr) for Specific Durations (minutes)							
	5	10	15	30	60	120	180	360
Bexon	106	106	104	81.2	60.6	50.8	40.9	31.5
Barre de L'Isle	76.8	55.2	49.6	34.4	27.4	21.6	19.1	16.2
Cap Estate	115	73.2	66.4	52.0	45.0	33.5	24.5	15.5
Mahaut	130	110	106	91.2	73.0	66.5	56.3	38.0
Soucis	98.4	84.0	78.4	68.4	56.4	43.7	41.1	33.4
Troumassee	96.0	75.6	64.8	42.0	28.0	23.1	19.7	15.9

Rainfall intensities for a selection of stations are presented in **Table 4.9**. The contouring for the 1 hour rainfall intensity is given in **Figure 4.6** but is limited by the data base used.

It can be seen from **Table 4.9** and **Figure 4.5** that the peak intensities and total rainfall depths during the storm varied significantly across the island. The heaviest rainfall fell over the central highlands around, and particularly to the south of, Mount Gimie (e.g. Bathe Nursery, Union Vale, Mahaut and along Cul-de-Sac valley) with stations at lower elevations recording lower depths. Watersheds particularly affected were Troumassee, Soufriere, Canaries, Anse la Raye and Roseau.

During TSD, there was a distinct east-west pattern in the rainfall depths recorded with the stations in the rainshadow along the west coast recording lower depths than may have been expected given their altitude. This phenomenon was not observed during the event of the 26th October and, with the exception of Soucis, all coastal stations recorded below average rainfall depths.

Estimates have been made of the return periods of the short duration rainfalls of October 26th and are presented in **Table 4.10**. Again, it should be emphasised that these are indicative because of the paucity of the short duration rainfall data base (efforts should be made to analyse historic chart records from the autographic recorders).

TABLE 4.10 ESTIMATED RETURN PERIOD (YEARS) OF RAINFALL EVENT OF 26TH OCTOBER

Station	Estimated Return Period (years) of Event for Given Duration			
	1 Hour	2 Hour	6 Hour	24 Hour
Bexon	50	60	>100	20
Barre de L'Isle	<2	<2	2	2
Cap Estate	2	2	<2	2
Mahaut	50	60	>100	100
Soucis	30	40	>100	50
Troumassee	<2	2	2	2

NOTE: These values should not be used for any purpose other than as approximate first estimates.

Based on extrapolation from data from Union Agricultural Research Station.

Figure 4.5 Rainfall Isohyets for 25th & 26th of October 1996

Based on 14 rainfall stations (excluding Barre de L'Isle) - 2 day total rainfall in mms

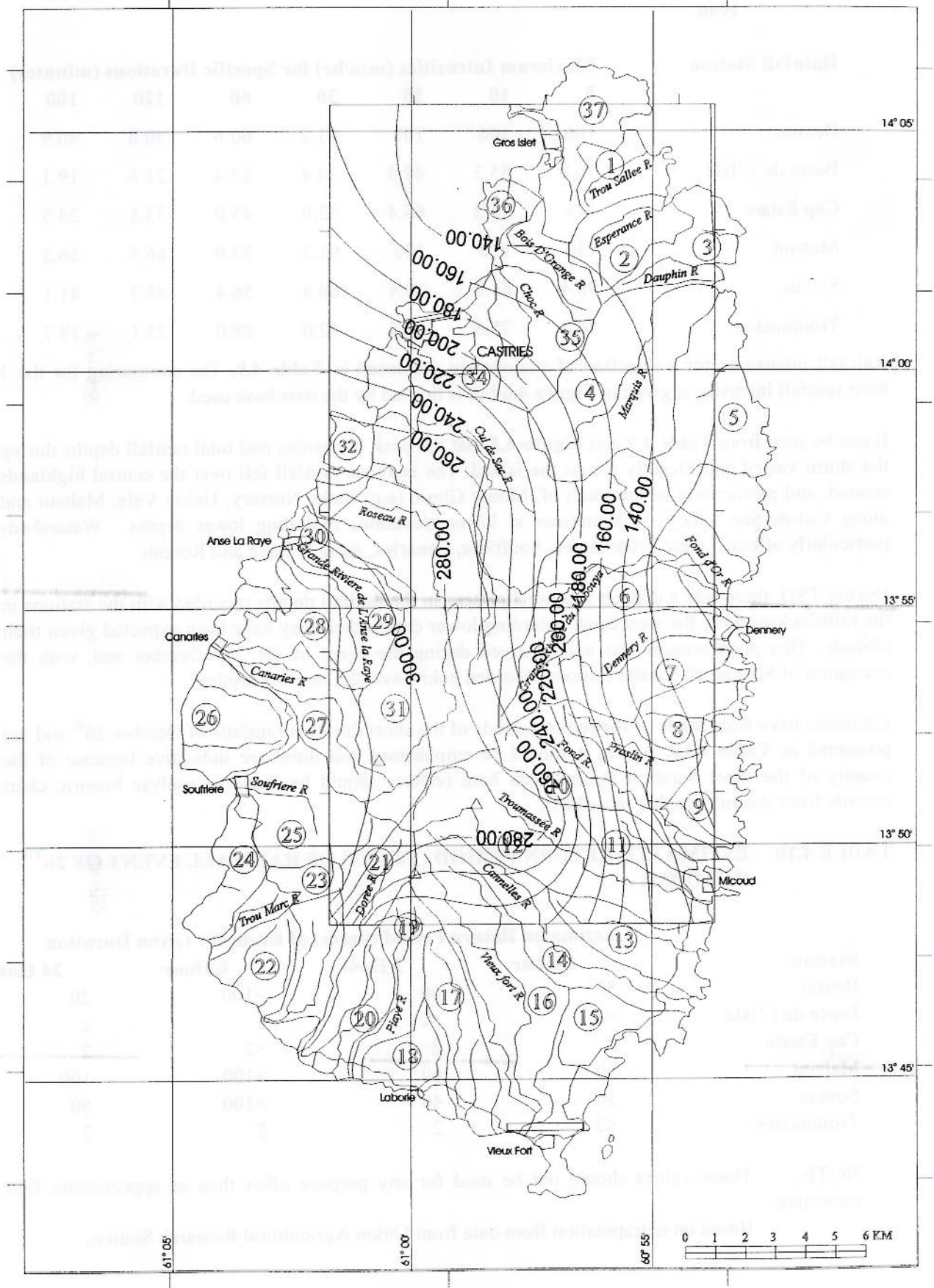


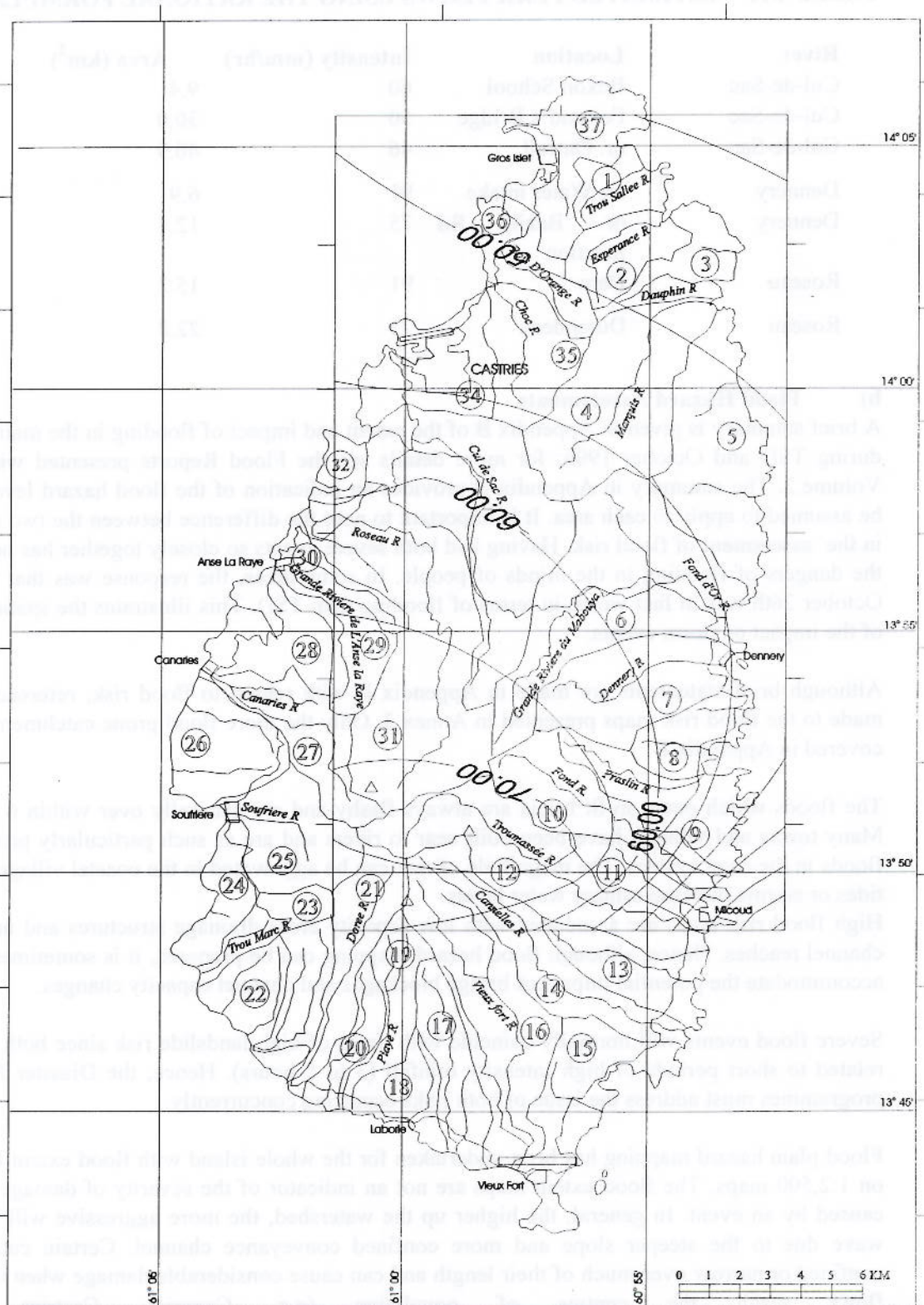
Figure 4.6

Rainfall Intensity Distribution (October 26th 1996)

Based on intensities for :

Bexon, Cap Estate, Mahaut, Soucis and Troumasse (5 stations)

Note, No 'Barre de L'Isle'



Clearly there is a significant variation in estimated return period which may be due to natural variations in the rainfall depth falling during the storm, but is also likely to be due to the inapplicability of the Union statistics to the gauges in the central highlands. The Barre de L'Isle gauge is considered to be recording unrepresentative data due to the proximity of tall pine trees; the data should be ignored and the gauge re-sited. The estimated resulting flood flows in some of the major rivers of the country are given in Table 4.11.

TABLE 4.11 ESTIMATED PEAK FLOWS USING THE RATIONAL FORMULA

River	Location	Intensity (mm/hr)	Area (km ²)	Peak Flow (m ³ /s)
Cul-de-Sac	Bexon School	60	9.4	110
Cul-de-Sac	Ferrand's Bridge	50	30.0	292
Cul-de-Sac	nr. Outfall	46	40.9	366
Dennery	nr. Water intake	91	6.9	123
Dennery	nr. Bazile Rd junction	75	12.1	177
Roseau	Dam	91	15.2	269
Roseau	Durandean	73	22.8	324

b) Flood Hazard Assessments

A brief summary is given in Appendix B of the extent and impact of flooding in the main catchments during TSD and October 1996: for more details see the Flood Reports presented with Annex 3, Volume 2. The summary in Appendix B provides an indication of the flood hazard level which can be assumed to apply to each area. It is important to note the difference between the two storm events in the assessment of flood risk. Having had both severe events so closely together has helped imprint the dangers of flooding in the minds of people. In some areas, the response was that the event of October 26th was in fact worse in terms of flooding than TSD. This illustrates the spatial variability of the impact of storm events.

Although brief statements are made in Appendix B with regard to flood risk, reference should be made to the flood risk maps presented in Annex 3. Only the more flood prone catchments have been covered in Appendix B.

The floods which occur in St Lucia are always flashy and are generally over within 6 hours or so. Many towns and villages have been built near to rivers and are as such particularly prone to severe floods in the river system. The magnitude of risk can be aggravated in the coastal villages when high tides or storms increase estuary water levels.

High flood risk areas are associated with low capacity cross drainage structures and undercapacity channel reaches. Hence, although flood hazard mapping can be prepared, it is sometimes difficult to accommodate the potential impact of bridge blockages and channel capacity changes.

Severe flood events will normally coincide with times of high landslide risk since both are strongly related to short periods of high intensity rainfall (3 to 5 hours). Hence, the Disaster Preparedness programmes must address the issue of both risks occurring concurrently.

Flood plain hazard mapping has been undertaken for the whole island with flood extent lines marked on 1:2,500 maps. The flood extent maps are not an indicator of the severity of damage likely to be caused by an event. In general, the higher up the watershed, the more aggressive will be the flood wave due to the steeper slope and more confined conveyance channel. Certain catchments are confined or narrow over much of their length and can cause considerable damage when the funnelled flows reach the centres of population (e.g. Canaries, Castries, Dennery).

Figure 4.7 provides an indication of the areas within each watershed which are particularly prone to flooding. For specific locations, reference should be made to the 1:2,500 flood extent mapping which has been carried out.

Infrastructure which was affected by the floods associated with TSD and of October 1996 are in danger of being affected by future flooding situations. That infrastructure affected and those dwellings which were damaged during TSD and October 26th 1996 should be addressed as part of the WMAF activities and recommendations made for flood proofing, flood protection measures or for the relocation of the structure.

The flood flows experienced in a normal season do not create many problems. Some bananas and other agricultural production can be lost but this can be generally associated with the cultivation being undertaken within the floodplain and often very close to the river bank. Some flooding of urban areas takes place on a regular basis and is associated with under-capacity cross drainage structures or badly located dwellings.

Severe flooding resulted from the rainfall and storm events of TSD and October 1996 affecting both agriculture and the rural and urban infrastructure (see Annex 2, Appendix B and C). These were floods of a relatively high return period depending on the river catchment in question. For the majority of the Island the event of TSD was the worse, although for some catchments on the west coast, the flood flows of 1996 were considered to be more severe, possibly due to the changes in river morphology brought about by TSD.

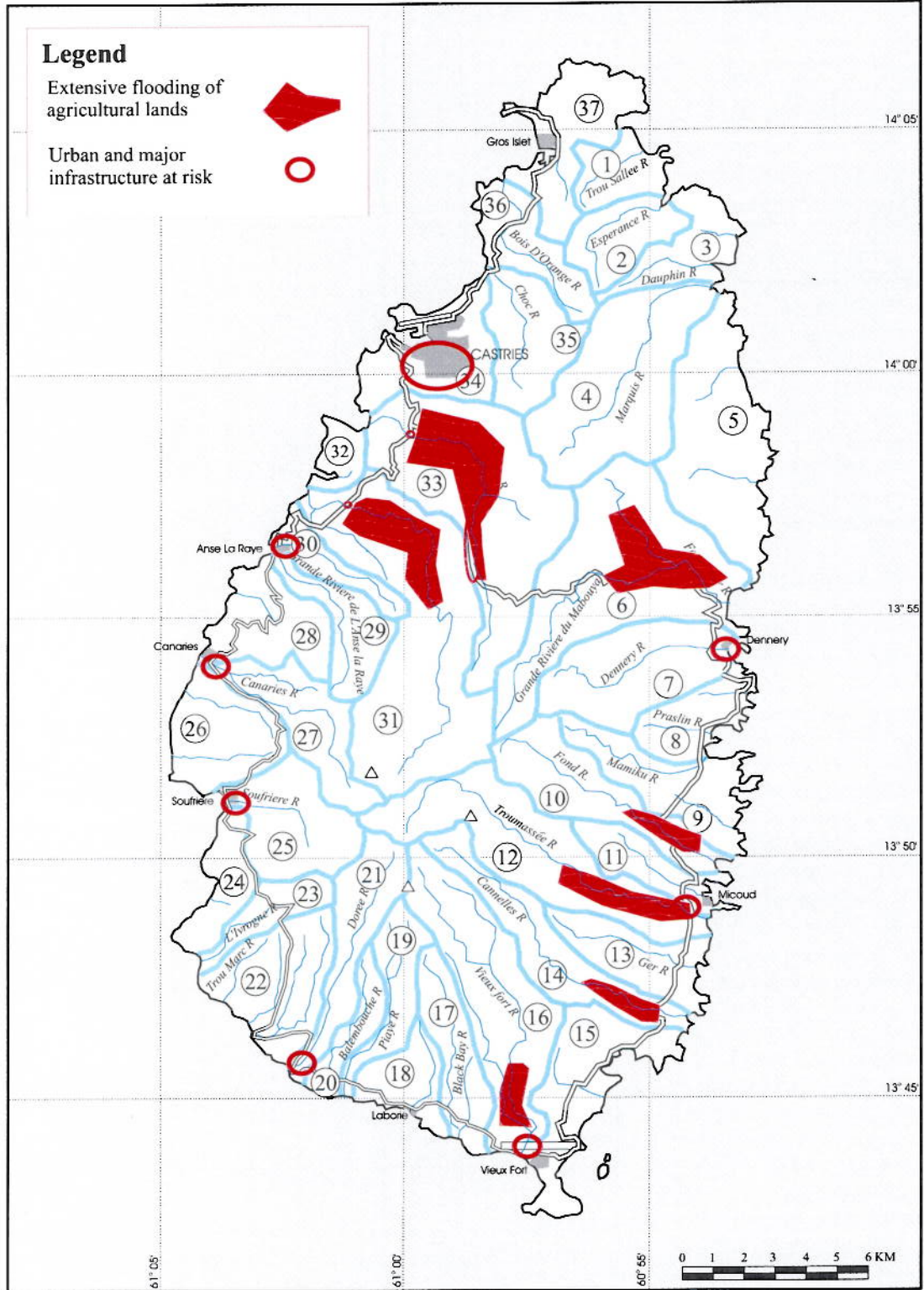
Agricultural land in the lower regions of the main river valleys of Cul de Sac, Roseau, Mabouya, Troumasse and Fond were flooded to depths of between 0.5 and 1.5m during both TSD(1994) and October 1996 although the absolute values naturally varied from place to place in the flood plains. In many instances, the flood depth was not the problem for the bananas but the velocity of flow and the forces on the stems of the plants. Velocities of flow in the main channels of these rivers were estimated to be between 2 m/s and 2.5 m/s during the main flood period of October 26th with flow velocities on the flood plains probably of the region of 0.5m/s to 1 m/s. The interface between these two flow regimes would be near the river banks where higher water pressures would be brought to bear. In addition to the problems caused by the physical flow of the water was the impact of floating debris on the standing bananas. Build up of debris on the stems increased the flow resistance and hence the overturning force aggravating the situation. Swathes of banana plants were flattened as was evidenced in all the above valleys during both flood events.

During severe flood events, many of the cross drainage structures are unable to pass the full stream discharge without overtopping and/or by-passing. The active flood plain is larger, generally extending across the full alluvial plain of the lower catchments resulting in considerable damage to banana plantations and other flood plain agriculture.

The high floods which pass down the floodplain will tend to deposit the sediment loads derived from erosion of the upper catchments. The lower velocities of flow and shallower depths of flow will tend to encourage the deposition of sediment on the flood plain areas. The sediment also gets deposited in the open drainage system of the plantations on the flood plain and thereby reduces the quantity of sediment entering the marine environment. It is believed there is a net positive build up of sediment on the flood plains during severe flood events.

FIGURE 4.7

Flood Hazard Mapping - Main Problem Areas



The response to the floods of TSD of straightening the meandering routes of the main rivers in the larger alluvial plains through loop cutting will reduce the amount of flood plain flow and hence tend to increase the quantity of upper catchment sediment which passes out to sea. The increased channel slopes resulting from meander loop cutting will increase flow velocities increasing the sediment carrying capacity of the river hence accommodating the probably increased sediment loads. The destabilisation of the natural river morphology and the creation of unprotected virgin new river embankments will also tend to increase the amount of river channel erosion which takes place. The effects of the 'new channel system' are considered to be an indirect impact of the severe floods.

c) Flood Hazard Mapping

Useful maps of the river network exist with the 1:50,000 map (Rainfall and Drainage System, Land and Water Use Unit, Ministry of Agriculture, 1984) providing an adequate base map of the main channel network. Other map series at 1:25,000, 1:10,000 and 1:2,500 also exist. Contours on all series are based on those shown on the 1:25,000 map series.

River surveys carried out as part of the Phase 1 Programme provide additional detailed information in relation to the lower sections of the river network. This is supplemented by the 1:2,500 maps in most parts of the basins, these being of two types, one topographic with contour information and the other Cadastral (land ownership information).

Flood extent mapping was undertaken in the period July to August 1997 and plotted on a set of 1:2,500 prints. The flood extents of TSD and October 1996 have been digitised using Autocad, the .DXF files have subsequently been imported in to the ArcInfo GIS system at CEHI for record purposes and for plotting of flood extent maps at 1:10,000. These computer files are also to be kept on the GIS system of the Ministry of Planning. The full set of marked up 1:2,500 map prints have been bound and left at the AESD Offices for record purposes and future reference when needed. A greatly reduced map of the compilation of plots for the Cul de Sac Watershed is shown in **Figure 4.8**.

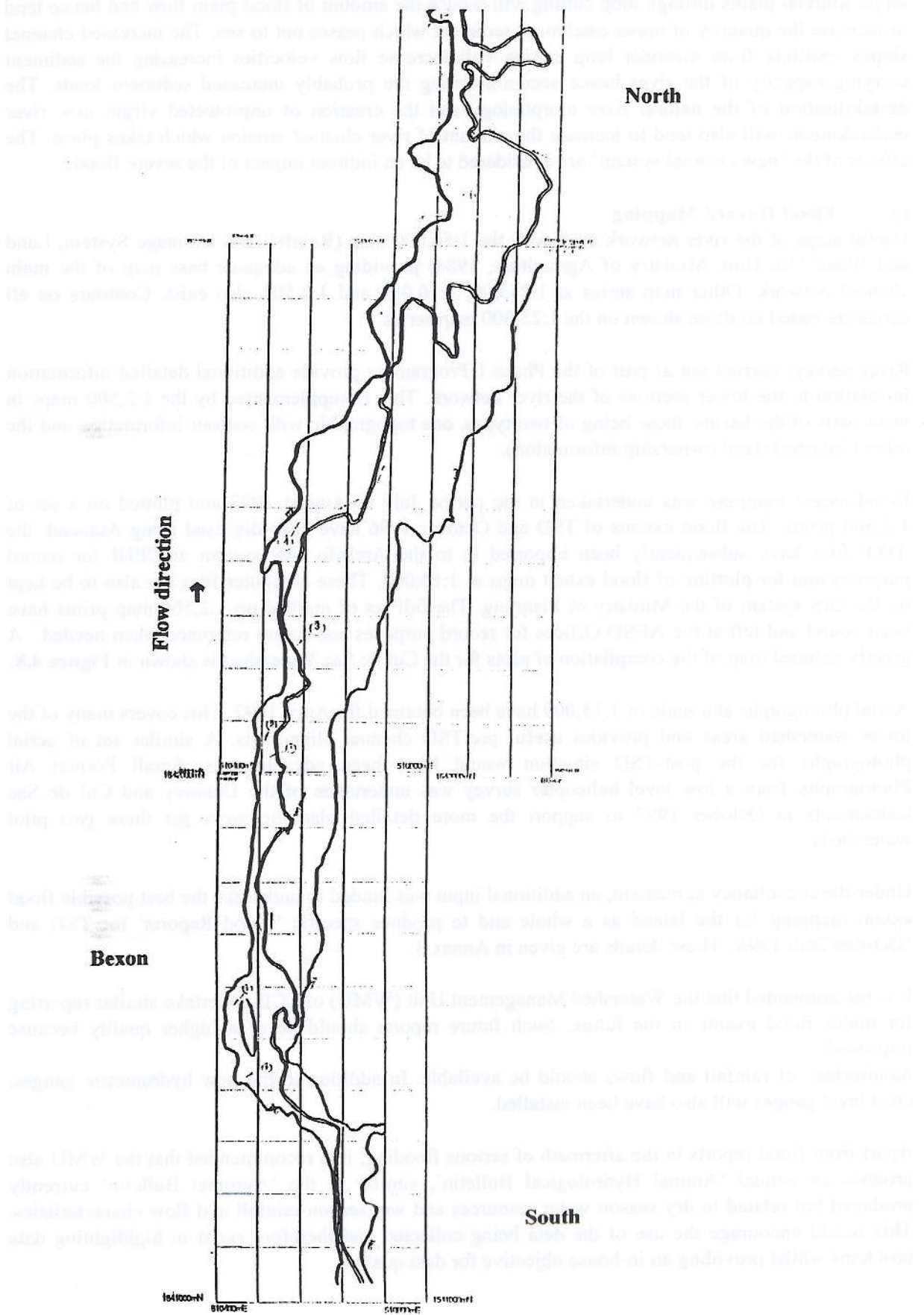
Aerial photographs at a scale of 1:15,000 have been obtained for April 1992. This covers many of the lower watershed areas and provides useful pre-TSD channel alignments. A similar set of aerial photographs for the post-TSD situation would have been advantageous. Small Format Air Photography from a low level helicopter survey was undertaken of the Dennery and Cul de Sac Catchments in October 1997 to support the more detailed planning work for these two pilot watersheds.

Under the consultancy agreement, an additional input was funded to undertake the best possible flood extent mapping for the Island as a whole and to produce specific 'Flood Reports' for TSD and 'October 26th 1996'. These details are given in Annex 3.

It is recommended that the Watershed Management Unit (WMU) of LCB undertake similar reporting for major flood events in the future. Such future reports should be of a higher quality because improved monitoring of rainfall and flows should be available. In addition to the new hydrometric gauges, crest level gauges will also have been installed.

Apart from flood reports in the aftermath of serious flooding, it is recommended that the WMU also produce an annual 'Annual Hydrological Bulletin', similar to the 'Agromet Bulletin' currently produced but related to dry season water resources and wet season rainfall and flow characteristics. This would encourage the use of the data being collected and therefore assist in highlighting data problems whilst providing an in-house objective for data quality.

Layout of the Autocad.DXF files created showing the extent of flooding



d) River Engineering

River Works to be undertaken through the Watershed Management Plans will comprise both river training and possible realignment as well as maintenance programmes. Although some traditional river engineering works will be identified through the WMAF, the majority of this will be undertaken under the normal annual works programme of the Ministry of Communications, Works, Transport and Utilities.

Programmes of flood protection works involving embankments are not envisaged for anywhere other than major roads or centres of population.

It is important that river maintenance and the removal of debris is regularly undertaken before the intrusion destabilises the channel through increased bank erosion etc. Such maintenance will reduce the need for river training and channel alignment control whilst also reducing soil loss from the river banks.

Measures which can be undertaken include:

- gabion (boxes or mattresses) protection work to prevent lateral movement of the channel and erosion of the outer banks of a bend;
- revetments with the same objective;
- palisading with the same objective;
- gabion work to provide a hard nib to provide a degree of stability to the alignment;
- palisading or gabions to create a groyne to redirect flows;
- desilting channels after major floods in particular and in areas of important infrastructure or housing (to avoid increased bed levels elevating water levels and thus causing flooding);
- loop cutting with associated mini weir construction if a head loss is to be created to match that lost in the cut. Care has to be taken with such weir design.

In almost all of the above measures it is important to introduce different levels of bio-engineering.

At key sections of some rivers, topographic surveys should be undertaken to monitor channel movement both laterally and vertically. This is particularly important near to major centres of population in case bed levels rise, impacting on flooding by pushing up water levels. These sections should be resurveyed on a regular basis, perhaps once a year but at least after every major flood event. Channel desilting/ de-stoning should be undertaken if significant bed level changes have occurred. Hydraulic checks should be undertaken since channel widening might be an acceptable alternative solution.

Lessons were learnt from the works undertaken during Phase 1 which were in response to TSD. These lessons are presented in the final chapter of Annex 1.

Recommendations for river engineering works are also presented in Annex 7 under the 'Pilot Engineering Trials' section.

4.3.2 Water Resource Availability and Utilisation**a) Water Resource Availability**

The rainfall characteristics of the island are significantly skewed with on average 60% of the annual rainfall occurring in the period August to November inclusive (33% of the year). The period January to May inclusive has relatively low rainfall with no month with a major consistently low expectation of rainfall, although February to April is generally the driest period.

The distribution of annual rainfall across the Island is given in **Figure 2.1** (Chapter 2). The isohyets represent the average annual totals at 23 principal rainfall stations for the period 1985 to 1995 inclusive. This period has the best checked and reliable records.

The water resources of the island are predominantly surface based with no natural surface storage (lakes). Groundwater resources are limited and located primarily in the lower alluvial regions in the Cul de Sac, Roseau and other major river basins. These groundwater resources are reportedly very small and are not considered to be of any major use, although some small scale domestic water supply systems might be sustainable.

The dry season water resources of the Island are therefore the baseflows of the river system together with any run-off which results from rainfall during the dry season. The distribution of rainfall during the dry season is summarised in **Figure 2.2** (Chapter 2) indicating that there is little difference to the distribution format of the annual isohyets. Climatic summaries are produced regularly by AESD in their 'Agrometeorological Bulletins'. Resource estimates are presented in Annex 2, Appendix A, **Table A.14**.

The base flows in the watersheds depend on several factors including:

- catchment area;
- soil types and their depth and waterholding capacities;
- land use and vegetation cover both in terms of reducing soil surface evaporation and influencing rainfall-runoff characteristics;
- abstractions from the river system by human intervention (irrigation etc).

In some areas, natural springs exist derived from interflow from the upslope soil masses. Some of these springs form the sources for water supply schemes e.g. Soufriere. Spring waters can be high in sulphur and other minerals whilst during the wet season most springs become larger and more plentiful (or evident).

Since 1995, the completion of the Roseau Dam has improved the water availability in the dry season in the northern part of the Island. The reservoir has a reported live storage capacity of 2.6 Mm³ (700 million gallons) when full; dead storage being reportedly about 0.35 Mm³. The catchment area of the reservoir is about 830 ha. With an annual rainfall in this catchment of about 3,000mm, the dam might yield an average runoff volume of about 25 Mm³ (see Annex 2, Appendix A, **Table A.16**). Evaporation losses from the reservoir could be of the order of about 0.5 Mm³ each year indicating that the replenishment of the annual storage volume is not a major issue. A problem possibly lies in the storage capacity of the reservoir in the context of soil erosion and sediment deposition. The catchment area of the reservoir comprises steep slopes in an area prone to high intensity rainfall and, hence susceptible to landslides, debris flows and general soil erosion. Estimates of sedimentation rates assumed in the development of the reservoir were of the order of 0.01% per annum although this has since been modified upwards. There are now reports that a delta bank has formed at the upstream end of the reservoir of about 200m length, (about 12% of the reservoir length) although depths will be shallow. (An erosion rate of 50 t/ha/annum over 830 ha is equivalent to about 0.1% of the live reservoir volume). The spillway and outlets pass water with low sediment concentrations in relation to inflows resulting in accumulation of solids in the reservoir storage area. The flushing of sediment out of a reservoir is always difficult.

Dry season flows in the lower reaches of the rivers of St Lucia can range from 100 l/s to 200 l/s for the larger watersheds in the central part of the island to zero in the smaller watersheds. There is a lack of dry season flow data and that which exists has not been referenced to the conditions during the measurements. Owing to the growing importance of water resources in the dry season both from a

perspective of the Water and Sewerage Authority (WASA) and the management of the enlarging irrigation sector, an intensive, comprehensive dry season flow monitoring programme is strongly recommended.

The inter annual variations in low flows can be large in percentage terms being a function of the preceding wet season rainfall volumes and the intermittent rainfalls which occur during the dry season. Indicative dry season river system yields are presented in **Figure 4.9**. (Note the isohyets shown are for a longer period than of **Figure 2.1** and is based on those presented in the World Bank Mission Report of December 1994).

The baseflows naturally vary with passage down the river system. In the upper catchments, where even though the baseflow generation is high in terms of l/s/km² of catchment, the volume flow is small, and this impacts against the needs of WASA in terms of diversions at their upper catchment intakes. More details are presented in Appendix A and Annex 2.

b) Resource Utilisation

Of the 37 identified watersheds on the island, 16 contain water intakes managed by WASA. The intakes are generally located in the upper parts of the watersheds to ensure good water quality. The intake structures divert water by gravity to basic water treatment plants where chlorination is the main activity. Details related to the WASA intake sites are presented in Annex 2, Section A.2.

Although the diversions are generally small, normally less than 10 l/s, there has been a continued need for WASA to resite some of their intakes higher up the catchments to ensure the quality of supply. The main reason for the resiting is the encroachment of agriculture, normally banana cultivation, on progressively higher and generally steeper ground.

In a report prepared in 1994, the population in 1991 was reported to be 136,900 (Annual Statistical Digest) and with an assumed population growth rate of 2%, a population in 1994 was estimated to be 145,000. A per capital consumption of 300 litres/day was assumed yielding a total demand of 15.88 million m³ per annum. Industrial demand was taken to add a further 3 Mm³. If 30% losses are added to these values then an overall resource demand is estimated to be about 25 Mm³/annum or a continuous flow of 800 l/s.

The 1994 Draft National Environmental Action Plan states that on average 6.5 mg/d was distributed in 1987 and by 1992 this had increased to 8.5 mg/d. This latter value is equivalent to 11.7 Mm³/annum and is assumed to relate to all but the agricultural sector. It is also reported that water shortages are common and that the figure is not equivalent to demand.

Irrigation demands as defined in the Rodriguez report² were based on an assumption that 2,200 ha were irrigated. Irrigation supply volumes of 7,000 m³/ha/annum were assumed for sprinkler systems and 10,000 m³/ha/annum for surface systems. This indicated a gross irrigation demand between 15 Mm³/annum and 22 Mm³/annum, with these demands being concentrated in the dry season. Assuming a 6 month irrigation season, this supply would be equivalent to an abstraction of about 1.25 m³/s (continuous over the irrigation season). In relation to the qualities of water on the Island, irrigation abstractions can be made from most river reach locations although information is required on the levels of pesticides in streamflows in the dry season.

2 Ref: H.V. Rodriguez entitled Water Resources Management and Development in St Lucia Post Tropical Storm Debbie, MoA, AESD 1994.

FIGURE 4.9 ESTIMATION OF INDICATIVE DRY SEASON CATCHMENT RUNOFFS

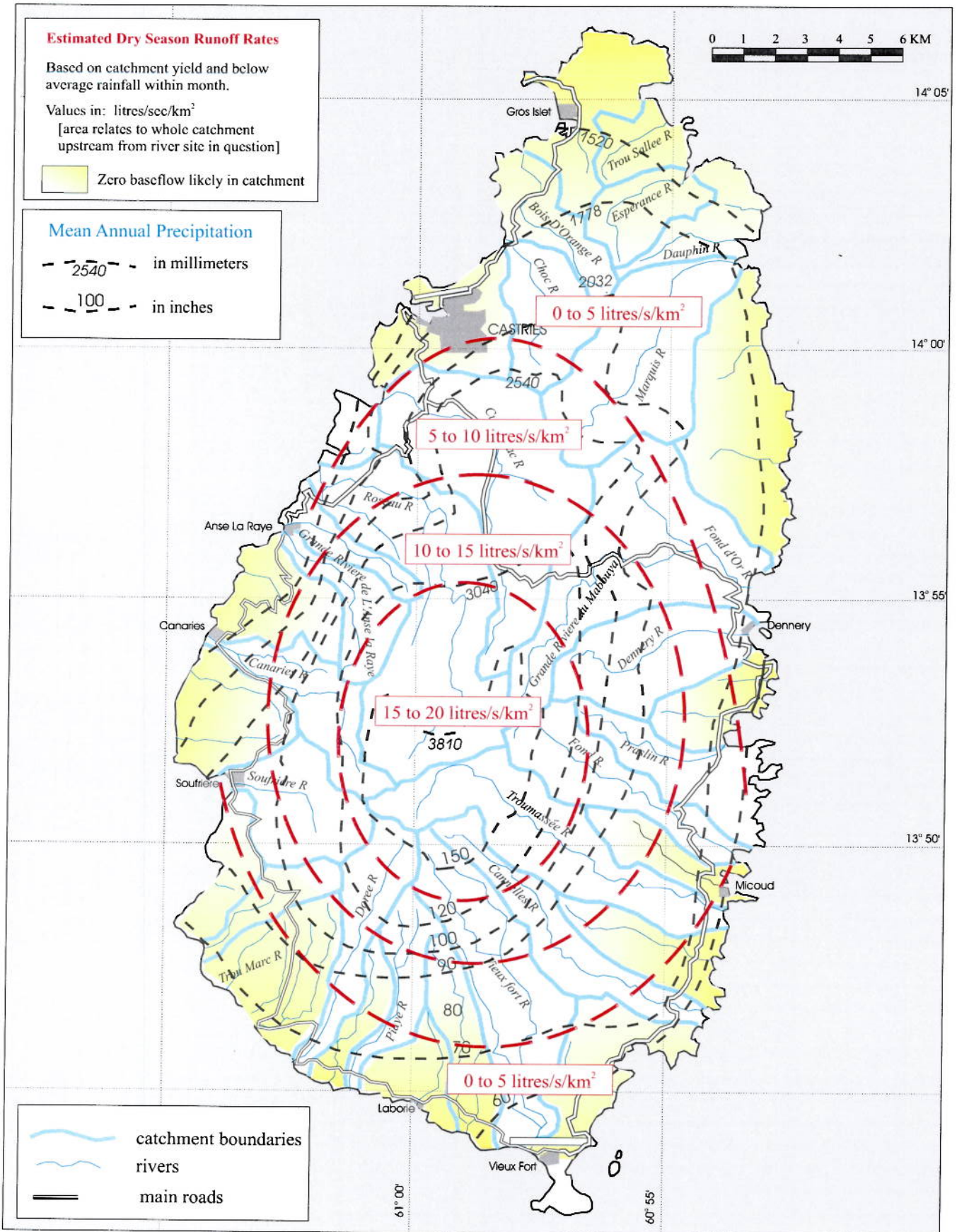


Figure 4.2

Indicative Topography of the Watersheds

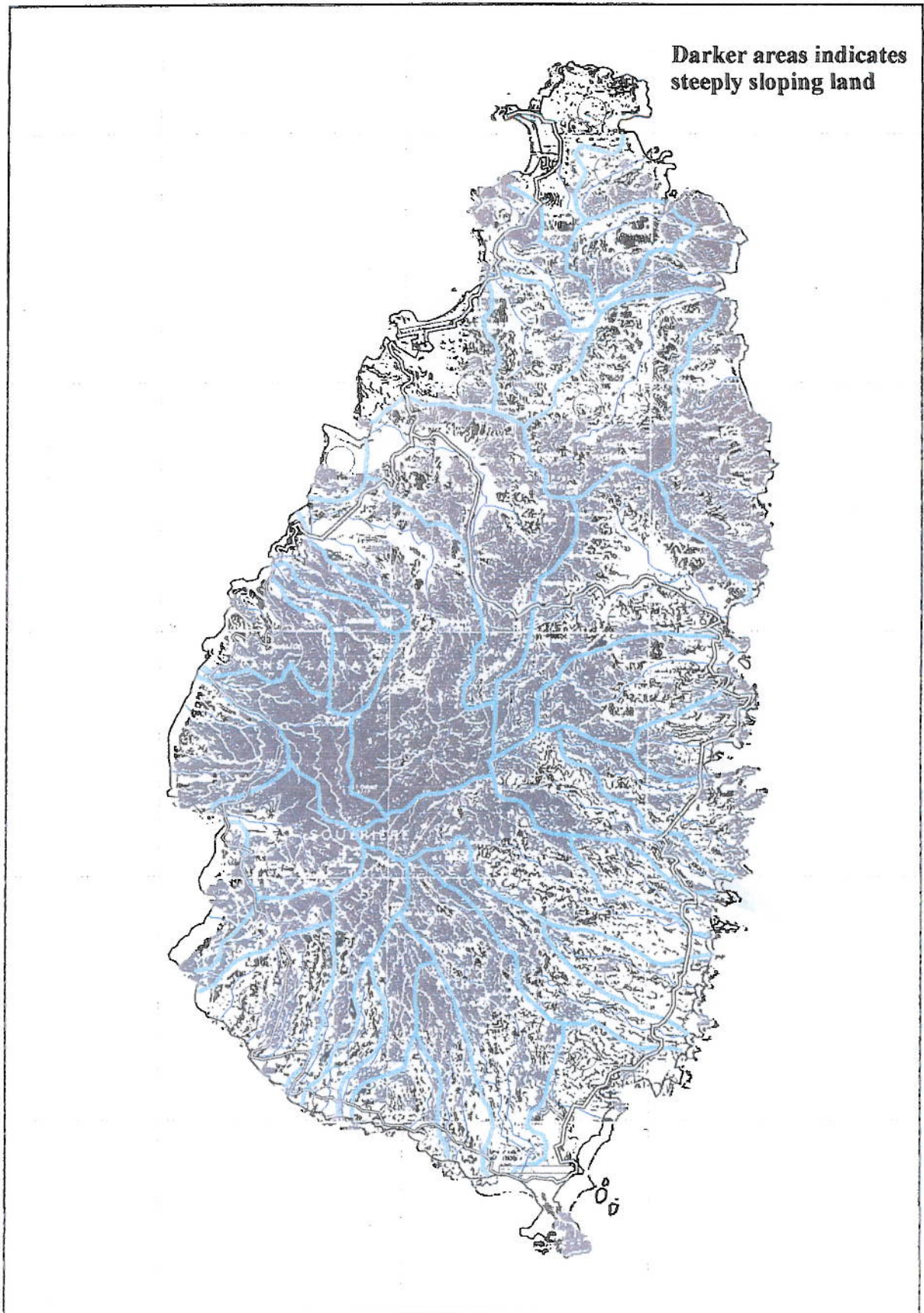


TABLE 4.3: LAND COVER / LAND USE LEGEND: SMALL FORMAT AIR PHOTOGRAPHY (SFAP) SCALE 1:5,000—1:7,500

Unit Subunit Mapped	Description	% bananas	Estimated soil loss, t/ha/yr, for slopes of:					Remarks on current rates of erosion: (Applies to land under average levels of management)
			2deg	15deg	25deg	35deg	50deg	
1a	Rain Forest (broad leaved)		0.1	1	3	5	Most of erosion through Mass Movements.	
1b	Montane Thicket							
1c	Mangrove							
1d	Elfin Woodland							
P	Plantation Forest Species		0.2	2	6	10	Assumes long-cycle plantatns; selectv felling, good mnmnt.	
2	Secondary Forest / Logged + -enriched Primary Forest		0.2	2	4	7	Most of erosion through Mass Movements.	
3	Scrub Forest		0.2	2	6	10	Soils more highly erodible for these areas	
4	Open Woodland							
5	Grassland / Scrubland		2	20	60	100	Assumes some seasonal cultivation (c 20% of area / yr)	
6	Commercial Agricultural Lands (eg Estates)						(Assumes higher % of good land, & better level of mnmnt)	
6b	V.intensive banana cultivation	90	7	14	40	60	Deep drains in alluv.land show appreciable erosion	
6bf	- " -, v.young plant crop, or currently fallow	(0)	14	25	60	100	Ground cover commonly poor.	
6bc	- " -, interplanted with coconuts forming 15-50% cover	65	4	8	25	50	Some protn.from surface wash, little from mass movmtns	
6cb	- " -, interplanted with coconuts forming 55-80% cover	35	2	4	14	30	Some protn.from surface wash, little from mass movmtns	
6g	Grassland (generally hydromorphic)		1	4	4		Permanent dense cover usual	
7	Intensive Small Farming							
7b	Intensive smallholder banana cultivation	80	10	20	60	100	Deep drains in alluv.land show appreciable erosion	
7bf	- " -, v.young plant crop, or currently fallow	(0)	20	40	90	150	Ground cover commonly v.poor.	
7bc	- " -, interplanted with coconuts forming 15-50% cover	60	6	12	40	90	Some protn.from surface wash, little from mass movmtns	
7cb	- " -, interplanted with coconuts forming 55-80% cover	30	3	6	20	45	Some protn.from surface wash, little from mass movmtns	
7bt	- " -, interplanted with treecrops forming 15-50% cover	60	6	12	35	60	Treecrops give better protcn from mass movements	
7tb	- " -, interplanted with treecrops forming 55-80% cover	30	3	6	17	30	Treecrops giving good protcn from mass movements	
7m	Mixed smallholder cropping	50	5	10	20	75	Fair coverage by treecrops/perennials	
7tm	Mixed smallholder cropping dom.by treecrops	20	3	5	15	25	Treecrops giving good protcn from mass movements	
7t	Smallholder treecrops	0	2	4	12	20	Well established trees / complete ground cover	
7r	Seasonally cultivated and/or bare soil surface	0	40	90	200	500	Massive erosion, especially on steeper slopes.	
8	Mixed Small Farming							
9	Rural Settlement (houses, yards, and immediate houseplots)		6	12	40	90	Combines area of mixed cultivatn, plus high runoff area	
10	Urban, Periurban/Residential, Commercial, Institutional, Industrial							
10i	Industrial/Institutional		6	12	40	90	Combines area of mixed cultivatn, plus high runoff area	
10h	Residential / Homegardens		6	12	40	90	Combines area of mixed cultivatn, plus high runoff area	

Complex Units include:

2/1; 2/7t; 5/7m; 5/7t; 7c/5; 7t/2; 7t/5.

Note: First unit in complex assumed to occupy 60% of area of the complex, second unit 40%.

Note: estimates on erosion include both surface wash and mass movements, averaged on yearly basis. Erosion estimates are of the Consultants, largely based on comparisons with: Hunting Technical Services Limited, June 1984. The Roseau, Dennery, and Cul de Sac Drainage and Conservation Project.

LTS, RDC, HTS, March 97. Sri Lanka: Upper Watershed management Study (ADB PPTA). Land Resources, Land Use Planning, and Watershed Management Aspects.

Note: Above legend is an enlargement, with small modifications, of the Hunting Technical Services 1984 legend.

TABLE 4.4: LAND USE OPTIONS AND IMPLICATIONS: (LAND OF 30 DEG SLOPE AND DEEP SOIL PROFILE)

LAND USE OPTION	ABUNDANCE OF DEEP TAP ROOTS (ANCHORING SOIL TO BEDROCK)	RISK OF LANDSLIDES [Probability of slides over next 50 Years] (Avg soil-loss:t/ha/yr)	INFILTRATION RATE (mm/day)	RISK OF SURFACE WASH EROSION (Average Soil Loss: tonnes/ha/year)	EVAPOTRANSPIRATION Crop Coef(Kc)	IMPLICATIONS FOR LAND MANAGEMENT	IMPLICATIONS FOR WATER MANAGEMENT
1. Natural Forest	Abundant	F. low [1%] (2t/ha/yr)	High 40mm	V. low (5t/ha/yr)	High (1.20)	Land Use sustainable, but little immediate financial returns/ha.	F. clean surface run-off High base flow/surface runoff ratio.
2. VP Tea (mature)	F. common (shade trees)	High [10%] (20t/ha/yr)	F. high 34mm	F. low (20t/ha/yr)	Mod. high (0.95)	Land Use sustainable, but requirement for v. good management.	Reasonable surface run-off; high base flow.
3. Forest Plantation or Perennial Treecrops (mature)	Common	Moderate [5%] (10t/ha/yr)	High 40mm	Low (10t/ha/yr)	High (1.15)	Land Use sustainable, but requirement for vg trash management.	Reasonable surface run-off; high base flow.
4. Forest Plantation or Perennial Treecrops (young: first 10 yrs)	Rare (only beginning to be re-established)	High [10%] (20t/ha/yr)	F. high-High 37mm	Low (10t/ha/yr)	High (1.00)	Land Use sustainable, but requirement for vg trash management.	Reasonable surface run-off; high base flow.
5. Bananas: good trash management + tied contour drains	Absent	High-v. high [20%] (40t/ha/yr)	High 40mm	F. low (20t/ha/yr)	Mod. high (0.95)	Land Use on limit of sustainability; requrmt for v. good managmnt	Reasonable surface run-off, mod. silt & nutrient content; high base-flow
6. Bananas: good trash management + surface drains	Absent	High [10%] (20t/ha/yr)	Moderate 34mm	Moderate (50t/ha/yr)	Mod. high (0.95)	Land Use probably not sustainable	Surface run-off with high silt and nutrient content
7. Bananas: poor trash management + surface drains	Absent	High [10%] (20t/ha/yr)	F. low 25mm	High (100t/ha/yr)	Moderate (0.90)	Land Use definitely not sustainable	Surface run-off with v. high silt and nutrient content
8. Seasonal Crops: eg. Taro	Absent	V. high [50%] (100t/ha/yr)	Variable: generally F. low. 25mm	V. high (500t/ha/yr)	Low (0.70)	Land Use definitely not sustainable	Surface run-off with extremely high silt and nutrient content

The main irrigation areas are shown in **Figure 4.10**. This is a very basic presentation since an inventory of irrigators has not yet been compiled although efforts are currently being made to assemble the information.

Current planning by Government envisages more irrigation with an FAO study on irrigation potential about to begin. A pilot irrigation project is being planned for the Roseau catchment, presumably to take advantage of the regulation provided by the Roseau Reservoir. Co-operation with WASA will be required.

Overall Island demand was thus estimated to be between 34 Mm³ and 41 Mm³/annum with a peaking in the dry season when resources are limited. These are relatively approximate estimates since they do not consider any re-use of irrigation drainage water and are based on many assumptions.

The national water supply characteristics to households was covered by the 1991 Census and the relevant national statistics are presented in **Table 4.12**. Almost 50% of dwellings had individual household supplies although this is heavily weighted by the conditions in the north of the Island. In Anse la Raye on the other hand, only 20% of households had direct supplies.

The improvement in domestic water supply systems is also presented in **Table 4.12** indicating a doubling in the number of house connections each 10 years. In 1970, only 12% of households were connected; in 1980 this number had risen to 24%, whilst in 1991 it was 48%.

On the basis of these characteristics, the per capita consumption level of 300 l/c/day (litres/head/day) is considered to be high.

The approximate characteristics of some of the WASA intake structures are presented in **Table 4.13**: more details are given in Annex 2, Appendix A. The location of the WASA intakes is presented in **Figure 4.11**.

The demands imposed on some of the offtakes are sometimes high, with those associated with Saltibus, D.Rivierre, Choiseul, Soufriere and Vieux Fort being the most critical. However, several of the other intakes are not endowed with totally sustainable catchment yields if dry years are encountered.

Seen problems with regard to direct WASA off-takes include:

- clogging of river intakes during floods, aggravated by upstream catchment land use changes;
- recurring droughts in the dry season, with different degrees of severity in different catchments.
- main supply pipeline ruptures;
- inadequate water treatment units especially on the smaller intake and distribution systems;
- insufficient revenue to WASA to enable it to operate effectively;
- reliability of supply in relation to demand.

FIGURE 4.10

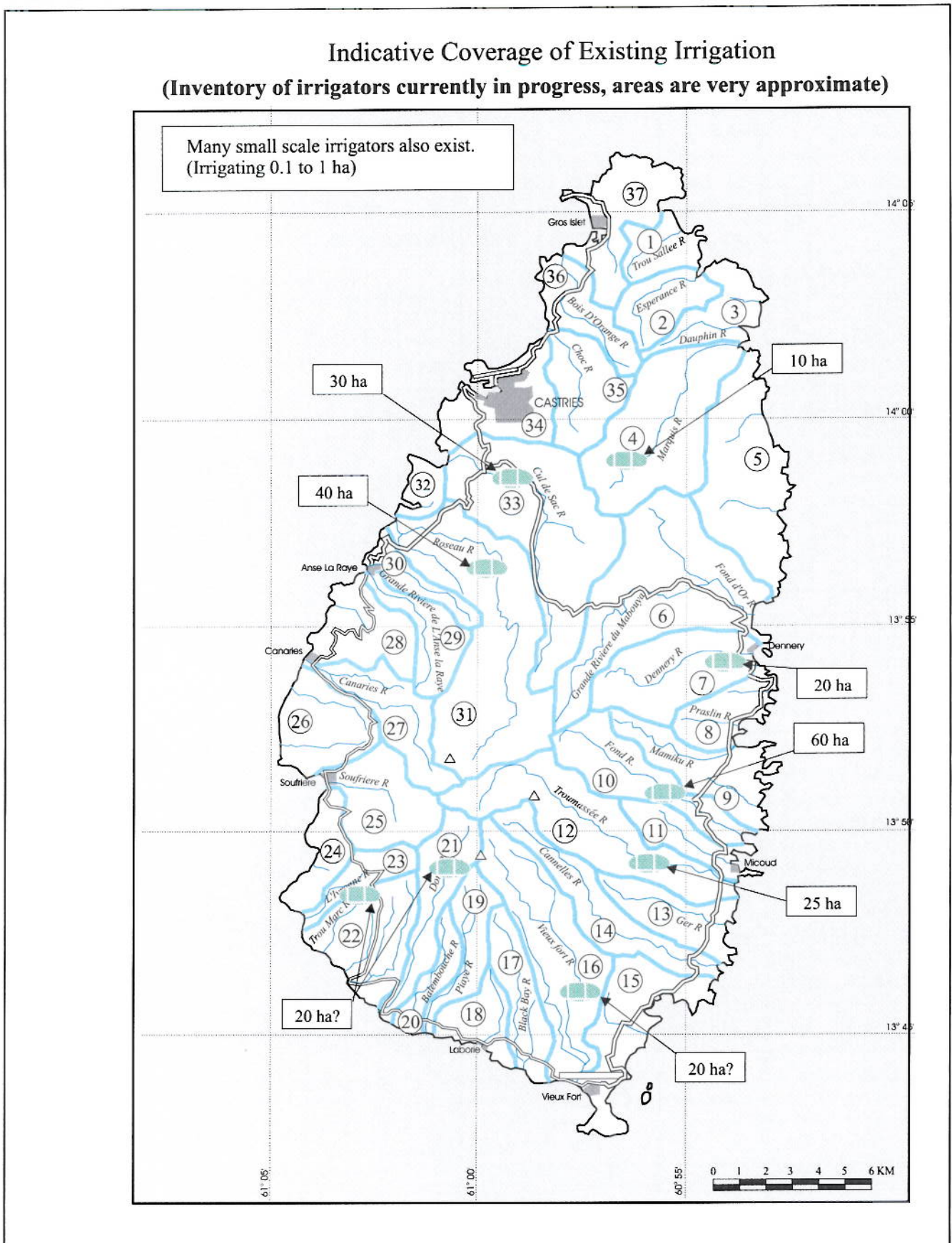


FIGURE 4.11

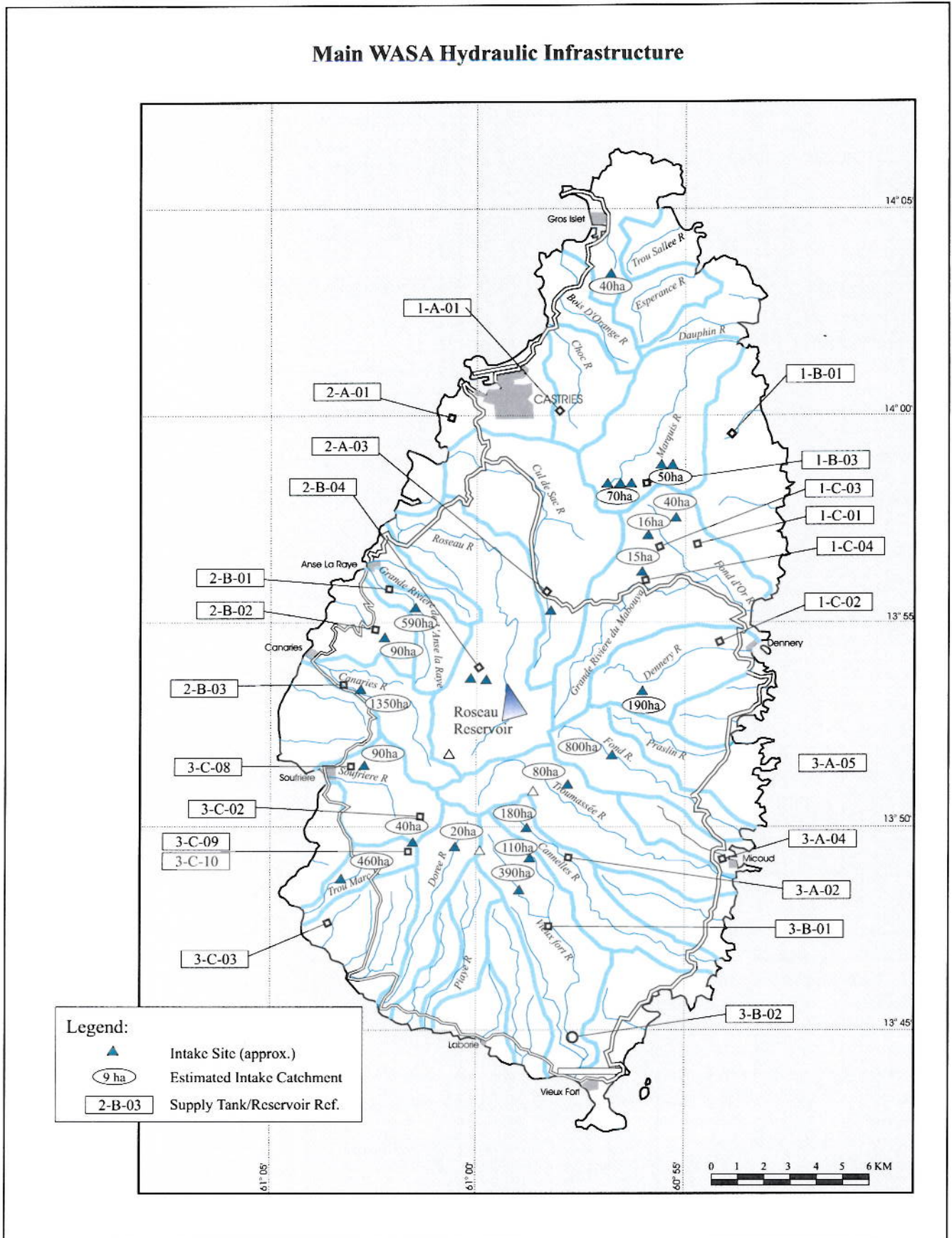


Table 4.12 Source of potable water supplies by source and district in 1991

Supply Type	Castries	Anse la Raye	Canaries	Soufriere	Choiseul	Laborie	Vieux Fort	Micoud	Dennery	Gros Islet	Island
Piped to dwelling	61.3%	21.2%	32.1%	50.5%	29.0%	31.8%	39.5%	36.3%	30.4%	55.5%	47.7%
Piped to Yard	10.8%	7.1%	1.2%	7.4%	13.1%	16.6%	22.9%	35.2%	18.6%	9.0%	14.9%
Private catchment	2.1%	1.1%	1.2%	2.9%	4.0%	5.8%	2.0%	0.5%	0.3%	2.7%	2.1%
Public standpipe	20.1%	62.1%	62.7%	31.0%	33.1%	38.3%	26.5%	17.6%	48.8%	29.1%	28.3%
Public well/tank	0.8%	1.1%	0.8%	0.3%	1.9%	0.7%	0.6%	0.3%	0.2%	0.4%	0.7%
Other	4.9%	7.4%	2.0%	7.9%	18.9%	6.8%	8.5%	10.1%	1.7%	3.3%	6.3%
Public supply cover	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total Population	92.2%	90.4%	96.0%	88.9%	75.2%	86.7%	88.9%	89.1%	97.8%	93.6%	90.9%
Population not serve	53,034	5,135	1,835	7,837	6,533	7,641	13,403	15,389	11,391	13,775	135,973
	4,137	493	73	870	1,620	1,016	1,488	1,677	251	882	12,374

Source: Table XI of 1995 Annual Statistical Digest 1995, p133

Development of the Water Supply Sector

Supply Type	1970	1980	1991
Piped to dwelling	11.6%	23.3%	47.8%
Piped to Yard	8.9%	15.5%	14.8%
Private catchment	4.8%	4.0%	2.1%
Public standpipe	40.6%	40.7%	28.3%
Public well/tank	0.5%	0.5%	0.7%
Other	33.6%	16.0%	6.3%
Public supply cover	100.0%	100.0%	100.0%
	61.1%	79.5%	90.9%

Source: Table XI of 1995 Annual Statistical Digest 1995, p133

{slight rounding errors}

TABLE 4.13

Water Supply (WASA) Intake Characteristics

Supply Area	Source Demand (l/s)	Catchment Area (km ²)	Catchment Demand (l/s/km ²)
Au Leon	5.3	-	-
D. Riviere	7.9	0.16	49.3
Dennery	10.5	1.9	5.5
Patience	4.7	8	0.6
Micoud	6.3	0.8	7.9
Belle Vue	6.3	1.8	3.5
Saltibus	3.6	0.2	17.9
Anse la Raye	2.2	5.9	0.4
Choiseul	5.3	0.2*	26.3
Delcer	7.9	4.6	1.7
Fond St Jacques	6.9	?	-
Soufriere	11.8	0.9*	13.2
Canaries	27.1	13.5	2.0
Vieux Fort	63.1	5	12.6

There are plans to develop new sources particularly in the east and southern parts of the Island to facilitate the development of tourism. The cost of the programme which should be completed in 1998 has been estimated to be about EC\$137m. Studies are ongoing in relation to the development of a new supply system in the Vieux Fort Watershed. The proposals will probably entail the development of a small water retaining structure. However, suitability of site, costs and resources are being assessed.

A National Water Conservation Plan was also deemed necessary although it is believed this has not yet been effected. An increase in water catchment areas by 2,000ha was indicated as being required. The current approximate catchment area of WASA intakes is about 5,000ha, with an additional 830 ha for the Roseau Reservoir.

Many of the WASA intakes are being affected by the gradual development of the upper catchment areas of the main river basins. The development, primarily agricultural and based on an expansion of banana cultivation, particularly over the last 10 years has resulted in several different impacts at the WASA intake sites:

- greater levels of turbidity during periods of heavy rainfall;
- reduced baseflows due to the changed catchment coverage of vegetation;
- greater risk of pollutant contamination of the streamflows due to the introduction of agro-chemical usage;
- greater risk of damage and blockage to the intake structures and of damage to the delivery pipelines through more flashy flood flows due to the changed catchment characteristics;
- the increased population levels which imposes greater stress on the reduced dry season flows in the streams through human activities.

These developments have resulted in the movement of intake sites further upstream, reducing the potential baseflow contribution and potential intake capacity and also, in many case requiring considerably longer delivery pipelines and hence risk of their damage. The locating of intake sites higher in the catchments has also often led to problems of operation and management of the facilities.

Concern by WASA over activities within the catchments of their intakes often goes unheeded unless the activities are occurring within Crown Lands areas where the Forestry and Lands Department can take action. More control needs to be imparted to an organisation such as the LCB in order to protect at least the existing WASA catchments.

The process of re-location has served to maintain the ability of WASA to provide continued supplies to date. However, growing demands and reduced catchment areas and baseflow yields dictate that the movement of intakes further into the upper catchments is unsustainable. There needs to be a policy of guaranteeing good quality baseflows and a systematic programme of relocating intakes to sites which will meet the needs of the future. Watershed and catchment management is an essential component of the future development in the Island and requires that far tighter controls on agricultural development and agricultural practices need to be enforced.

If the alternative to tighter watershed management is the construction of new reservoir facilities, the economics would clearly favour the former. Reservoir sites are limited whilst the cost of their development is large. Few suitable reservoir sites exist whilst their susceptibility to sedimentation questions their sustainability. It currently makes more sense to enhance the natural reservoir system in the catchments, securing good quality baseflows of sufficient volumes to meet both drinking water supplies and the needs of the aquatic ecology in the various river systems.

The monitoring of the dry season flows, both in terms of discharge and qualities is currently poor and only occasional dry season flow gauging are undertaken.

4.3.3 Water Quality Issues

a) Dry Season

Sources of contamination of the surface water system during the dry season are both agricultural and domestic. Since there are often rain showers even in the dry season, agricultural waste is still liable to enter the natural drainage network. Field visits have indicated that pollution from domestic activities can be as problematic and these include:

- people washing themselves and their clothes in the rivers;
- washing of motor vehicles;
- seepage from water closets and septic tanks;
- contaminants from domestic refuse dumped near or in the river.

In addition the following can give rise to problems:

- contaminants from small industries, garages etc;
- debris from banana packing stations, spillage of agro-chemicals being a risk.

During the dry season dilution ratios are small and hence any contamination can be problematic.

Most of the above listed contamination problems are found normally in the lower reaches of the river system and the quality of the water impacts on both the users as listed above and on the aquatic ecology system.

Since the dry season flows are generally small and pollution of the river system is not normally very serious, the adverse impact on the marine environment is slight. Problems are more likely to be found in localised pools near centres of population where water movement is small and hence potential contamination is high.

In the upper catchments where the majority of the WASA intakes are located, pollution from domestic sources is rare and the major problem is seen to be that derived from agriculture (see Annex 2, Appendix A, Section A.5). However, this carries concerns in the form of agro-chemicals. WASA are sometimes compelled to move their intakes further upstream when a potential pollution source is identified. In these catchments more intensive monitoring of activities is required.

The catchments where relocation of the intakes is being considered include:

- Dennerly - agricultural encroachment into the catchment area immediately upstream
- Canaries - human interventions in the existing catchment
- Anse la Raye - water qualities at risk from tourist visits to upstream waterfall and pool area
- Delcer - already moved 200m upstream; the old site being too close to road

Currently, WASA have no planned programme of retreats. However, they are aware of the problem intakes and will take action when necessary, but the cost of a new intake is relatively high and there is an understandable tendency to delay moving.

Water quality monitoring is undertaken on many of the waters delivered by the intakes, testing including chlorine levels, turbidity measurements and coliform counts. The testing is undertaken by the Ministry of Health and covers about 270 water delivery points across the Island. This includes standpipes and household taps supplied from the 29 sources (serving a population of about 130,000). Owing to a lack of facilities and equipment, testing mainly means checking chlorine levels. Water quality testing for agro-chemicals is more complex and is not undertaken as a matter of course.

When chlorine levels are very low, tests are sometimes carried out of bacteriological levels (coliform counts) and the facilities at CEHI are used for this purpose. High chlorine levels result in check being made of the operation of the associated treatment plant.

It is important to instigate a regular water quality monitoring programme to be operated and managed either by the Ministry of Health or the WMU. Laboratory testing facilities are required whilst an arrangement with CEHI needs to be established for the testing of agro-chemicals, at least in the short-term until facilities exist elsewhere.

Main pollution incidents are gauged by fish deaths, not a very systematic monitoring method even when it is carried out.

During the recently completed River Surveillance Project undertaken at CEHI through BDDC funding, testing for agro-chemicals was undertaken for some of the WASA intake sites; however, no significantly high levels of contaminants were found.

Another finding of the River Surveillance Project was the low biotic scores of the majority of the rivers in St Lucia. This low level of aquatic diversity and aquatic populations was considered to be due to the flow characteristics of the river system. This entails low and often uncertain dry season

flows, and high and very 'flashy' flood season flows, the latter tending to flush the system of small creatures whilst the former highlights a fragile life support system.

The water quality indicator used as the main element of the *River Surveillance Study (CEHI - ODA - 1993-7)* was that related to the biotic scores attributed to selected monitoring sites on the river system. The monitoring points selected were based on the network of WASA intake structures and other key locations in the natural drainage network.

The biotic score categorisation ranged from A to F - A being related to an indicator of very good water quality and the E grade of very poor quality (F indicated a dry stream). The Study covered the period 1994 to 1997 and encompassed the impacts of Tropical Storm Debbie and the severe storms and flooding of October 1996.

In general, the study found that the biotic scores (population densities and diversity of invertebrate families) of the river system in St Lucia were very low compared to other countries. This was primarily attributed to the nutritional inadequacies of tropical forest streams and the habitat instabilities imposed by the flashy nature of the stream run-off during the wet season. Less than 10% of the stream reaches studied were included under class A although many monitoring points were located in the upper catchments where good conditions might be expected.

Some of the results of the River Surveillance Study, augmented by observations derived from the current Study are presented by watershed in Appendix A to this Report. The resulting classification of the water qualities of the river network is given in the surveillance study Final Report.

From the watershed condition summaries presented in Appendix A, it is evident that there are many problems relating to the sustainability of diversions of good quality water from the catchments of the Island for domestic consumption. There is a need for improved water resources management, with this being based on a watershed unit.

b) Flood Season

During the flood season, the water quality problems change. Dilution ratios are generally high in relation to such inputs as seepage from water closets and clothes washing. However, the higher rates of runoff washes both soil particles and large amounts of waste debris into the river system. Apart from the high sediment loads, the other common debris being transported in the river system are:

- coconuts;
- plastic bottles and containers (sometimes ex agro-chemical bottles);
- glass bottles (normally rum);
- plastic bags, particularly the blue plastic sheeting used in banana cultivation.

The natural ecosystem related to the aquatic and marine systems will be accustomed to the entry of some sediment, organic matter and coconuts. However, the volumes of sediment transmitted to the marine environment have increased in recent years although the absence of any sediment measurement programmes for the river system means this cannot be confirmed. Experience, and research elsewhere indicate that higher rainfall intensities and increases in land area devoted to agriculture, without good soil conservation practices, lead to high rates of soil removal from catchments. Some of this eroded soil enters the natural drainage system to pass out into the marine environment.

Research studies by others on the west coast have indicated an increase in the deposition of soil sediments and 'blue plastic bags' on the important coral beds. However, this research and monitoring

work has only been undertaken over the last few years, a period affected by the impact of TSD and the flood of October 26th 1996.

In relation to the upper catchments and the WASA intakes, the wet season problems are dominated by high turbidity levels and the blockage of the intakes. The high turbidities can be very problematic leading to a need to sometimes close down the supply system. Despite having filters at the intakes, sediment still enters the pipeline system causing blockages and hence closures. High turbidities in the water delivered to customers are unpopular and result in many complaints which are also received when closures are necessary. Some of these issues could be addressed by better intake arrangements and improved treatment facilities.

4.3.4 Water Resources Management

It is considered essential that improved water resources management is undertaken on the Island, particularly related to the dry season resources. This should cover both the management of the resources and their use. Various Islands across the Caribbean are also realising that it is essential to protect their water resources. Efforts are made to remind the agricultural sector that farming within catchment areas is discouraged to ensure that pesticides in particular, are not washed into the supply system.

With an increasing population (c.2% per annum) and rising living standards (see growth in house connections) increased demands are going to put water supplies in term of both quality and quantity under pressure. With the anticipated growth and reliance on tourism as a major source of revenue – security of good quality water resources is essential. There is no room for mistakes (e.g. agro-chemical pollution incidents) since this could seriously impair the growth in tourism by bad publicity.

The fragility of some of the catchments producing water for WASA intakes has been clearly demonstrated. The construction of the Roseau Dam has relieved the pressure on supplies for the heavily populated northern part of the Island but many communities still rely on the baseflows of the natural drainage system. Studies are underway for the identification of secure water supplies for the southern part of the Island, probably through water storage facilities in the Vieux Fort Watershed. However, the options of water transfer from the Troumassee watershed should also be evaluated. This concept has been muted in the past for supplying Vieux Fort and also for augmenting the flows in the upper Roseau Watershed (which would now feed the Roseau Dam).

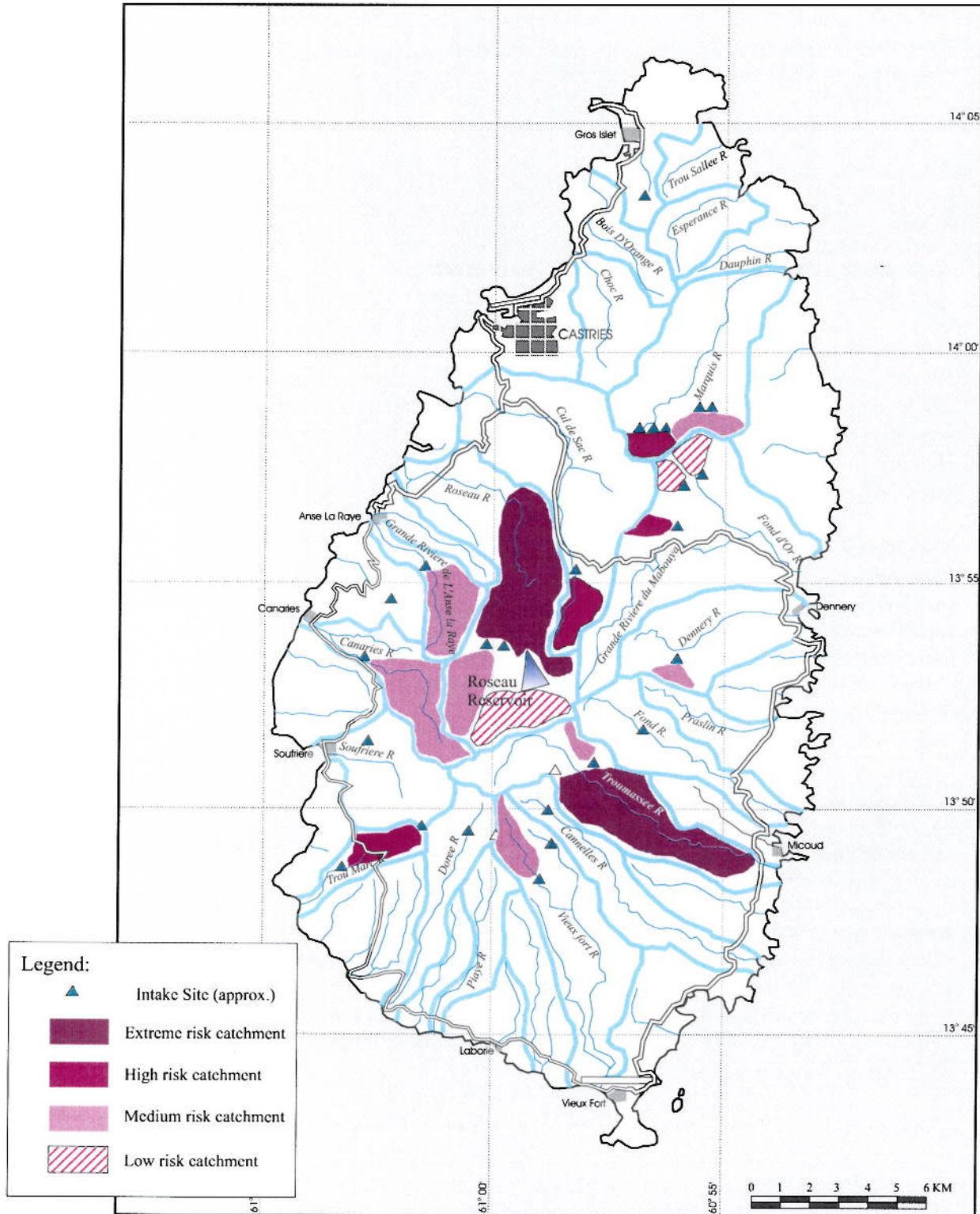
Every effort should be made to secure the resources in Troumassee Watershed for possible exploitation in future years (include in Long Term Government Strategy). Other watersheds which should be 'frozen' in terms of upstream developments include Canelles, Fond and the southern limb of the Grande Riviere du Mabouya.

An assessment which has not been undertaken is the ecological flows which should be maintained in the different parts of the various watersheds. At present there would appear to be a poor understanding of the need for minimum river flows with some of the intakes diverting the entire river flow during dry periods. Possible irrigation abstractions could leave a zero level residual flow in a river since there are at present no license limitations or any monitoring of river abstractions. This situation needs to be addressed.

The assessment of the dry season resource availability has been undertaken earlier in this chapter and has been used in Chapter 7 in the process of identifying the critical watersheds for prioritisation in the development of Watershed and Environmental Management Plans. Watershed resource assessments were also carried out in the early 1980s and a summary is to be found in an inset graph on the 1:50,000 'Rainfall and Drainage System' maps produced.

FIGURE 4.12

Main WASA Intakes and their vulnerability with regard to water quality



Source: River Surveillance Study, ODA/ERP

The importance of water resources management needs to be appreciated at the watershed level since it is within the control of the populations within the watersheds to modify their activities to minimise adverse impacts on the resources, both in terms of quality and quantity. This is particularly important during the dry season when base flows are extremely low and pollution is a major risk. The involvement of the WMAF in the management of the resources, both in the dry season and wet season should greatly improve the situation.

Organisations at Government level which have direct involvement in water resources issues in St Lucia are:

WASA -	Water and Sewerage Authority	- Water supply responsibilities; - Effluent discharges;
AESD -	Agricultural Engineering Services Division	- Rainfall measurement; - River flow measurement; - Irrigation advice;
EH -	Environmental Health	- Water quality & associated health issues (Relating to WASA operations only).

The main environmental laws which relate to the water resources sector are:

- Forest, Soil and Water Conservation Ordinance (1946);
- Water and Sewerage Authority Act (1984);
- Public Health (Water Quality Control) Regulations (SI 14/78);
- to a lesser extent the Litter Act.

The responsibilities of WASA would appear to include, on the basis of the 1984 Act:

- establishment of a hydrological network and the execution of periodic water surveys;
- prepare estimates of future water demands for the domestic, industrial and commercial sectors;
- preparation of plans for the execution of more efficient water management.

The water and sewerage regulations as applicable to WASA are stipulated in the statutory instrument document of 1995, Document Number 47.

As stated in the Institutions Report, (Annex 11), water is perceived to be a property of the State and there are no private rights over water. WASA has the responsibility to manage the water resources within a watershed including the safeguarding of water quality. It is also responsible for the management of droughts and to monitor resources to these ends.

Water qualities are covered under Public Health Regulations wherein are defined the water quality standards, and penalties for their infringement are laid out.

Important aspects which must be addressed both from the central legislative and technical instruction process and at watershed level through WMAF actions include:

- the permissible activities in the flood plains and the manner in which these are enforced;
- the control of trash ingress into the river system during flood periods;
- the regulation on the use or abstraction of water from the river systems in the dry season;
- the potential for charging systems and licenses for water abstraction and the monitoring of these abstractions;

- the control of activities which can cause pollution in the river system particularly in the dry season;
- the possibilities for the introduction of fines for pollution incidents.

In 1990, an FAO Water Legislation Specialist drafted a 'Water Resources Act' and other recommended legislation. The Water Resources Act was proposed to supersede the Water and Sewerage Authority Act of 1984 and incorporate the major provisions of the Land Conservation and Improvement Bill (1987). The work built upon a report produced in 1989 entitled 'Water Legislation and Management in St Lucia'.

The proposed Act was designed to address many of the issues and aspects raised above, and it is recommended that the proposals are revived.

Records are kept of the diversions made by WASA but no inventory exists of abstraction sites for irrigation systems. This inventory needs to be established. Additionally, the dry season river discharge monitoring programme needs to be made more systematic and regular. The dry season discharges would be mainly gauged by current metering. However, these values would need to be analysed in the context of upstream abstractions and the rainfall characteristics of the period prior to gauging.

It is recommended that at least an initial licensing of all abstractors from the river system should be instigated, with perhaps a nominal annual charge being imposed. Apart from facilitating an inventory of abstractors, it would also help in water resources monitoring.

Improved water quality monitoring is advocated, particularly of the river waters upstream of a WASA intake. Testing needs to be expanded to include monitoring the level of agro-chemicals, particularly pesticides, despite the fact that only one such positive test was encountered by the River Surveillance Study. The risks are too high for testing to be ignored because it is relatively expensive. Sampling should be undertaken, not only upstream of some of the critical WASA intakes but also lower down the river systems in the more densely cultivated areas to assess water quality impacts on the marine environment.

Water resources are very scarce in the dry season without much scope for major irrigation development. However, the data base related to dry season flows is small and needs to be improved to enable a forthcoming FAO Study to be well founded. An intensive dry season water resource evaluation is deemed essential incorporating estimates of dry season use and relating to antecedent moisture conditions and rainfall volumes. This would be compared with the work undertaken in 1985/86 under a UNDP funded project where a major current metering exercise was undertaken of the low flows at that time. However no water quality measurements were made, nor relationships derived with rainfall events or upstream water abstractions.

WASA water charges as currently applicable are summarised below:

Entity:	Rate per 1,000 gallons
Domestic	1 st 3,000 - EC\$ 4.10 > 3,000 - EC\$ 7.78
Commercial/Industry	EC\$ 10.28
Hotel	EC\$ 11.00
Government	EC\$ 6.40

In addition to the above, there is a relatively small service charge, generally about EC\$5 per month. These values are considered low by WASA and increases are being sought. Recent comparisons have been made between the charges imposed by the various water authorities across several of the islands of the Caribbean. For example the cost of water for households in St Vincent and the Grenadines is based on a standard fee of EC\$10/month plus the following consumption charges:

Consumption Ranges		Charge rates	
0-5,000 gallons	(0 to 18.9m ³)	EC\$ 5 per 1,000 gallons	(EC\$ 1.32 / m ³)
5,000-15,000 gallons	(18.9 to 56.7m ³)	EC\$ 8 per 1,000 gallons	(EC\$ 2.12 / m ³)
> 15,000 gallons	(> 56.7m ³)	EC\$ 15 per 1,000 gallons	(EC\$ 3.96 / m ³)
Industrial/Commercial		EC\$ 10 per 1,000 gallons	(EC\$ 2.64 / m ³)

WASA hope to increase supply tariffs from 5 EC\$ to 10 EC\$ per 1,000gallons (1.3 EC\$ to 2.6 EC\$ per m³), and complete metering on all properties.

The socio-economic impact of such controls and charging systems needs to be investigated. Initial indications are that there would be strong opposition to any charge for irrigation water. In putting the irrigation situation into perspective, an irrigation depth of 700mm per irrigation season, equivalent to an irrigation rate of 7,000 m³ per ha, would cost EC\$ 18,480 at the ‘commercial rate’ shown above. However, although water charges are imposed on irrigators in some countries, the levels are seldom comparable with potable water charges.

The important aspect of the above pricing analysis is that water has a value and where demand on a limited resource increases, a charging process or ‘water rights; agreements must be put in place. This is particularly important in relation to private sector agriculture and possibly a privatised WASA.

4.4 OTHER WATER RELATED SECTORS

4.4.1 Solid Waste

The St Lucia Solid Waste Management Plan is part of the OECS Waste Management Project and entails the construction of two new sanitary landfill sites and the closure of specific major dump sites on the island. Waste reception facilities are also proposed at ports. One of the new land fill sites is proposed for the Deglos area of the Cul de Sac watershed (as a replacement to the one at Choc originally proposed). The site at Vieux Fort is to be upgraded. Existing dump sites to be closed comprise Ciceron, Micoud, Dennery, Anse le Raye and Choiseul. It is also proposed that CEHI have a role in the environmental monitoring of the landfill sites.

One of the major concerns related to the more highly developed and populated catchments is the issue of solid waste management. The problems can basically be related to:

- need for better information dissemination and education on the need for solid waste management;
- lack of an effective solid waste collection system, particularly with regard to waste container design for the kerbside;
- lack of enforcement of controls over illicit dumping, particularly in drainage channels and rivers.

Garbage collection services are organised throughout most if not all of the Island, the kerbside collection being undertaken by contractors under contract to the Ministry of Health. In total there are about 20 garbage disposal contractors servicing the various communities. The contracts for garbage collection can range from EC\$5,000 to EC\$20,000 per month and are generally for a period of 2 years.

Standard terms of the contracts include elements covering:

- provision of garbage bins to residents of communities;
- provision of secondary garbage containers at strategic locations;
- clearance and removal of all indiscriminate dump sites;
- provision of twice weekly collection services;
- liaison with regard to public awareness campaigns and education programmes;
- removal and disposal of all dead animals and carrion;
- disposal of all collected garbage at agreed waste sites.

The conditions of the sample contract, if properly applied, would solve many of the problems identified. Issues which perhaps could do with better definition would relate to the form or design of the 'garbage containers' to be provided and the manner in which the kerbside material is to be held (plastic containers, bins etc?). The different contractors have different truck types, hence the form of container would probably depend on the equipment owned by the contractor and on the market price.

In future, the contracts will be let and managed by the newly formed Solid Waste Management Authority which will receive aid packages from donors including the British Government, the World Bank and the Caribbean Development Bank. The shortcomings of the existing system are known and the issues will be addressed in the near future.

The WMAF for a Watershed should liaise with the SWMA to ensure contracts are complied with and for WMAF to feed back recommendations for improvements in the collection process. The WAMF could also encourage the adoption of composting at house/farm level to reduce the volume of garbage being generated. Another area where the WMAF and SLBGA could play an important role is in the management of the blue plastic used to protect bananas during cultivation. Reducing the quantity of such plastic entering the drainage system would be a positive move. Finally the government might encourage the use of biodegradable plastic containers in the procurement of imported items.

4.4.2 Liquid Waste

The treatment and disposal of sewage is a problem for the Island which has not yet been adequately addressed. The use of septic tank soakaways by large sectors of the population which live in the lower river basin areas is reportedly producing contamination of coastal waters. Some sectors of the population still do not have access to even a water closet.

Only two proper sewer networks exist on the island, these being in Castries and the relatively new system in Gros Islet. The majority of the population is either served by septic tanks or water closets. - see Table 4.14 which summarises data from the 1991 Census.

Planning permission for new houses or the development of new septic tanks requires approval from the Department of Health for the siting and the design. New facilities are required to be sited no closer than 20m to 30m from a river course, but no such controls are imposed on water closets. Even though these limits are stated, their enforcement is reportedly weak.

The soil types, plot sizes and ground slopes often make the construction of septic tanks difficult and they may not always be constructed as designed.

No routine water quality monitoring is carried out of any drainage system, neither a natural drainage course near a highly populated area nor of any foul drainage system. If a pollution incident occurs, some tests may be carried out. However, the limited laboratory facilities are a constraint although some testing can be organised at the Victoria Hospital. The Environmental Health Act does require the monitoring of sewage effluents and presumably the major focus should be at problem areas or large communities or establishments.

**Table 4.14
Toilet Facilities by Household - 1991**

Disposal System	Castries	Anse la Raye	Canaries	Soufriere	Choiseul	Laborie	Vieux Fort	Micoud	Dennery	Gros Islet	Island
Linked to sewer	13.1%	3.7%	1.0%	0.8%	0.3%	1.0%	3.1%	0.2%	1.4%	5.0%	8.4%
Septic Tank	31.9%	8.4%	23.2%	42.6%	15.3%	22.7%	29.2%	25.6%	15.9%	43.3%	30.0%
Pit latrine	49.2%	49.2%	8.9%	28.8%	64.3%	64.1%	53.1%	53.1%	46.8%	45.8%	49.0%
Other	2.3%	17.5%	25.8%	14.4%	4.5%	0.8%	1.0%	1.9%	9.6%	0.6%	3.7%
None	3.5%	21.2%	41.1%	13.4%	15.6%	11.4%	13.6%	19.2%	26.3%	5.3%	8.9%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total Population	53,034	5,135	1,835	7,837	6,533	7,641	13,403	15,389	11,391	13,775	135,973
Population with 'other or 'none' facilities	3,076	1,987	1,228	2,179	1,313	932	1,957	3,247	4,089	813	17,133

Source: Table V of 1995 Annual Statistical Digest 1995, p130

There are currently no subsidies for water closet or septic tank construction and little monitoring of the performance of the systems in different parts of the Island is carried out. The WMAF could be involved in awareness campaigns and in passing on advice on siting and design to their community. It would also be useful to identify septic tanks and/or water closets which are deemed to be potential pollution sources to the river system or any tubewells should any exist in an area.

For the sewerage systems the charges for services are:

Entity:	Rate per 1,000 gallons
Domestic	1st 3,000 - EC\$5.45 > 3,000 - EC\$10.35
Commercial/Industry	EC\$ 13.7
Hotel	EC\$ 14.6
Government	EC\$ 8.50

For some of the major sewage systems, marine pipelines (outfalls) are used to dispose of the treated (semi-treated) effluent. Although an issue, it is considered outside the brief of WEMP, since it is a WASA main line task and needs special project support to improve the situation.

The growing population, increased water supplies and improvement in living standards will mean that there will be both spatial and composition changes in liquid effluent in the next 20 years. These changes need to be monitored and allowed for in the development and adjustment of WEMP.

4.5 OTHER ISSUES

4.5.1 Coastal Marine Environment

a) Siltation

Siltation in the near coastal zone was illustrated in a spectacular way during the Small Format Air Photography undertaken by the consultants on 16th October 1997 (see Photos in **Figure 4.4** and on the Report cover). Apart from any damage to coral and other marine life, the plumes of silt would have been very unpleasant to tourists in nearby resort areas - in this case Marigot Bay (between Cul de Sac and Roaseau Valleys) and La Toc Bay (to the North of Cul de Sac). As 16th October followed several days of relatively dry weather, the problems which would be experienced after heavy rain become even more alarming. In addition to silt being carried down the Cul de Sac River, the problem as observed in **Figure 4.4** would have been aggravated by two other factors: the recent arrival in the bay of the large oil tanker and its associated tugboats which clearly had churned up much bottom silt previously deposited in the bay; and also the new road project which has bulldozed enormous quantities of spoil material into the sea. Both of these types of activities clearly need to be monitored more closely by the NEC.

The Consultants on many occasions during the last 12 months have experienced turbid waters when swimming in three main areas: Coubaril Point (1km to the N of Cul de Sac River Mouth), Vigie Beach, and Choc Bay. In an island where the main industry is tourism, and where tourists are attracted mainly by the beaches and spectacular coastal scenery, this is of major concern. Tourism, as essentially a fashion industry, is extremely sensitive to adverse publicity, and thus turbidity in these three tourist areas must be afforded the greatest attention.

In other areas the marine siltation problem appears much less severe, with the sea to the north of Choc Bay being visibly very much clearer at all times. **Figure 4.13** shows the location of the tourist hotels (the size of the circles being approximately in proportion to the capacity of the hotel), and the main coral reef areas in relation to the main sources of siltation (the size of the triangle being proportional to the estimated annual volume of silt reaching the sea). With a predominant northerly current from the North, the main problem areas can be seen to be from Choc River to just south of Roseau Bay.

Recent studies in St Lucia on the impacts of siltation on coral reefs have included the very recent paper by Sladek Nowlis, Roberts, Smith and Siirila, covering damage caused in the period following TSD.

Studies covered siltation effects from three rivers: the Soufriere (Watershed 25), and the much smaller Anse Galet and Anse Mamin Rivers (small parts of Watersheds 28 and 26 respectively). The authors covered sampling points from 250m to 1250m from the mouths of these rivers. They found that TSD damage was considerable, with coral mortality exceeding 50% at the most heavily impacted site. Coral mortality was also correlated with depth of fine sediments in nearby areas.

The three rivers covered in the above study are notably less problematic in terms of volumes of silt likely to be washed into the sea during flood periods, which make these findings even more alarming. Although precise quantitative data is lacking, the Consultants noted that at times of high rainfall and flash flooding during the periods Sept-Nov 1996 and June-July 1997, that the worst rivers in terms of silt deposition were clearly the Cul de Sac, Roseau and Fond D'Or, but in terms of impact on beaches frequented by bathers, the Choc was the most problematic.

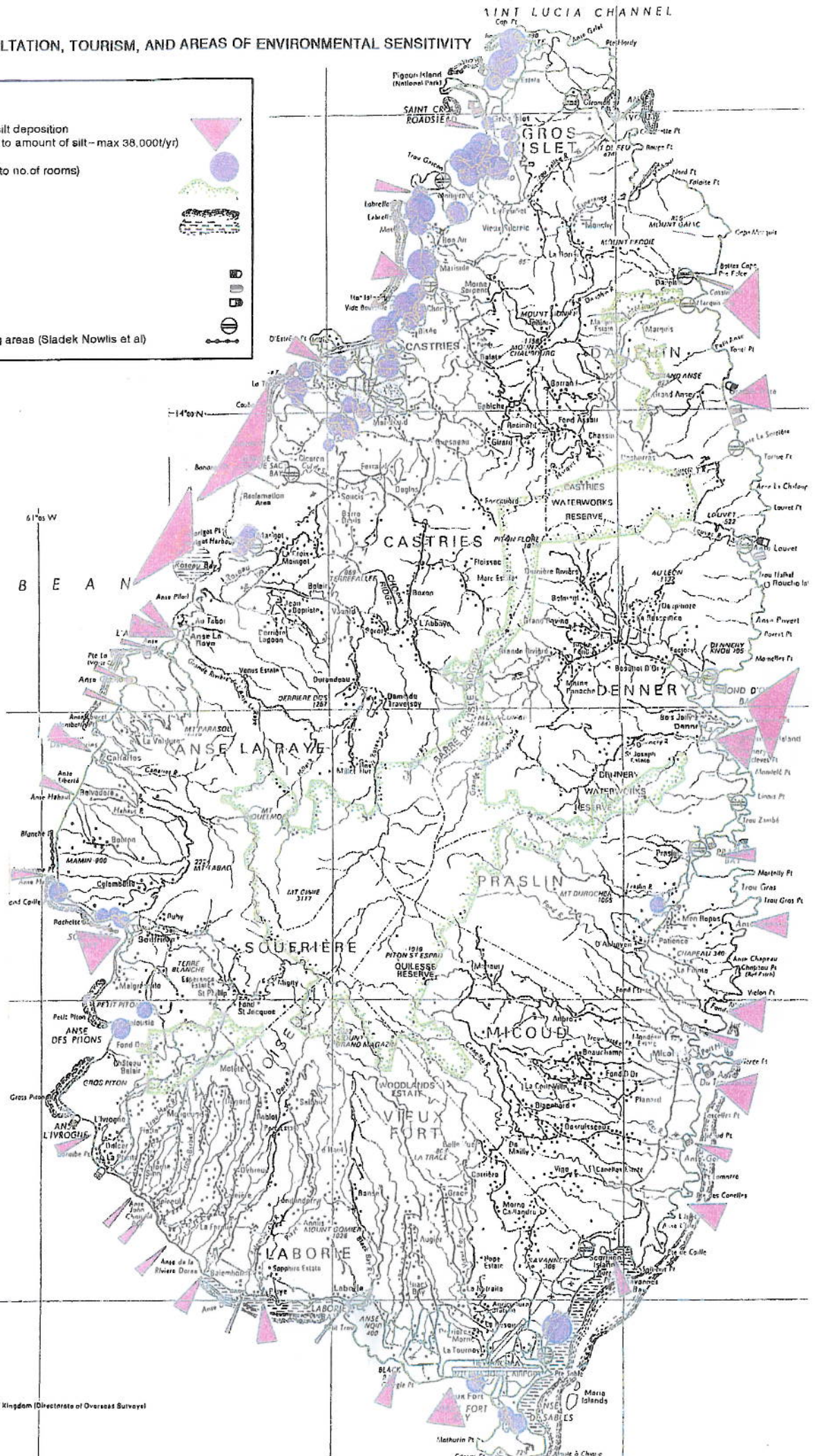
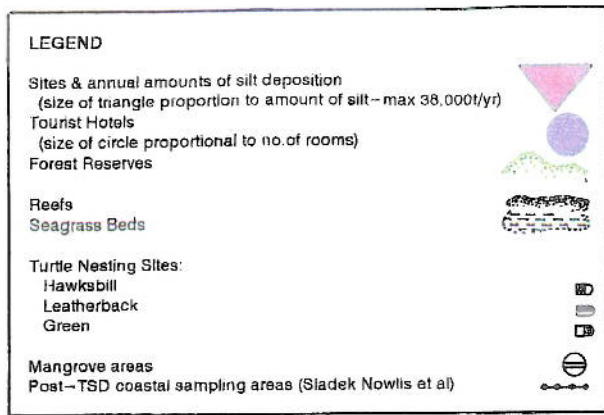
b) Solid Wastes

Solid wastes in the coastal marine environment include domestic rubbish, agricultural biodegradable waste (coconuts, banana trash, forest litter, branches and logs, dead animals etc), and non-biodegradable, mainly plastic waste (diothene sleeves, pesticide bottles). Much of this rubbish is carried to the sea every year by the 37 main rivers in the country. A large quantity becomes washed up on the beaches where it becomes unpleasant to bathers and local residents. Much plastic rubbish, particularly diothene tubing, becomes entrapped in corals and marine growth, where it is reported to badly affect the habitats of marine animals as well as the corals themselves.

Collection of domestic rubbish is let to contractors on price-sensitive contracts. Quality of collection is said to be poor in many areas, with much rubbish left uncollected for various reasons. On collection days rubbish is left by the side of the road in loose plastic bags where it is picked over by domestic animals, and at rainy times may be washed into the nearest streams.

In spite of these problems it would appear that the extent of environmental awareness of many local people is encouraging, at least with respect to rubbish disposal. The Dennery WMAF had notable success with its 'clean up' campaign, and local tourist hotels and public authorities do good work in keeping beaches clean, particularly after flood or storm events. MCWT&PU have put up signs by the side of many road bridges warning people not to throw rubbish into the rivers, and this appears to have had some effect. WIBDECO/SLBGA in their extension work is covering this as a priority area, with disposal of plastic containers and diothene sleeving being criteria for certification of banana growers.

FIGURE 4.13 MARINE SILTATION, TOURISM, AND AREAS OF ENVIRONMENTAL SENSITIVITY



Keeping streams free of fallen logs and branches and other organic waste has traditionally been seen by local people as the responsibility of MCWT&PU, but one of the functions of the WMAFs is to try to change this outlook, with the people themselves being responsible for keeping waterways clear. With the fall in the price of coconuts associated with the closing of the Soufriere factory (now just reopened) enormous quantities of uncollected coconuts have been washed down the rivers, where they contribute both to river scouring and to blockage of channels. The reopening of the factory will help this problem: the installation of trash lines in banana fields would also help, as the nuts from interplanted coconuts would get trapped on the lines rather than rolling downslope and into the drainage channels.

c) Liquid Wastes

Liquid wastes comprise domestic and ship sewerage, drainage waters from urban areas, and effluents from factories and agricultural processing facilities. Problems imposed by the wastes may be due to any or all of the following:

- harmful micro-organisms in the effluents themselves (faecal coliforms, pathogenic viruses, etc);
- subsequent decomposition of organic materials within the effluent, making the material and surrounding water anaerobic;
- harmful compounds or elements in the effluent (e.g. pesticide residues, heavy metals);
- oily materials forming a film on the water surfaces, and inhibiting aeration.

In St Lucia all of these mechanisms can be seen to be operating. With very little tidal difference (c 0.6m), and with little wave action and only weak currents on the Leeward (Caribbean) side of the island, these problems are aggravated. Both Castries Harbour and the marina at Gros Islet are almost completely enclosed and suffer badly from eutrophication due to influx of organic materials and mineral nutrients. Both areas now have strict requirements on non-dumping of sewerage and solid materials in the sea, but both areas show problems due to previous accumulation and to current influx of materials from the land. The high population density in both of their watersheds further aggravate the problems. Solution to these problems lies in firstly ensuring that all houses have flush toilets emptying into suitably-sited septic tanks, and secondly that any domestic and agricultural organic residues remain on the land and are not washed into streams. River reserves and trash lines would both help in this respect.

Marigot Bay, which is more open than Castries Harbour but more enclosed than other bays along the Leeward Coast, has incipient problems of eutrophication, associated with accumulation of silt materials and algal blooms. Floating oily deposits and organic residues were observed by the consultants during several visits.

Monitoring of river water or sea water for faecal coliforms and other harmful organisms is not routinely carried out. CEHI have facilities for these analyses but do not carry out routine monitoring functions. Sampling undertaken on previous projects have shown that all coastal communities have 'sewage-driven water quality problems along their shores with typical bacterial counts often being in excess of international health standards. One coastal community studied in Summer, 1994, had faecal coliform counts in excess of 8 million per 100ml in the river and 80,000 in the marine water.'

St Lucia has been moderately successful in attracting light industry, most of which do not show major water pollution problems. The one big exception to this, observed by the consultants, is the rum distillery in the Lower Roseau Valley which in June/July 1997 was causing major problems to the Lower Roseau River, colouring the water black and giving very strong smells of anaerobic decay. A neighbouring farmer complained bitterly that he could not use river water for supplementary irrigation, and his problem was aggravated by the river straightening associated with the Phase 1 works.

4.5.2 Terrestrial Fauna and Flora

Small Caribbean Islands, in spite of showing a wide spectrum of agro-ecological zones with vastly different rainfall regimes, do not show very high bio-diversities per square km in comparison to continental areas. Thus numbers of bird, animal and plant species would be much less, for example, than a similar climosequence across the Orinoco watershed in Venezuela. Ecological buffering is also much less in these islands than in continental areas. Thus an introduced insect pest, for example, is likely to be much more of a problem in St Lucia than in Continental areas because the number and variety of predators in St Lucia would be much less.

However, the islands are noted for their endemic species, and the numbers of endemics per square km would be higher than that for continental areas. In the case of birds St Lucia has 5 island endemics, of which three are endangered (St Lucia Parrot, St Lucia wren and Semper's warbler). In addition there are 10 regional endemics, of which three again are endangered (the forest thrush, the rufous night jar and the white breasted thrasher).

Habitats for these endangered species include the central rainforest areas (the St Lucia parrot) and the dry seasonal woodland in the north-eastern parts of the island (the thrasher and the wren). The mangrove areas are also under threat, with less than 200 acres remaining. Current conservation programmes have been fairly effective in raising the level of awareness for the conservation of both endangered species and their habitats, and several areas have been targeted for conservation programmes if not brought directly into nature reserves.

Current dangers at the moment centre on further expansion of the road network, both agricultural feeder roads which will probably be targeted at inland areas (and pose a further threat to the remaining central rainforest areas) and the proposed Chinese-financed highway, which will cut through habitats of the endangered thrasher and the wren.

4.5.3 Health Issues

Health issues relating to watershed management include water-spread disease vectors: mosquitoes, sandflies and snails.

St. Lucia is free of malaria and habitats for the malarial mosquito (water in generally rural areas in bright sunlight) are generally less common than that for other mosquitoes. However, vectors for dengue fever and yellow fever are much more common, these mosquitoes breed in relatively clean water (e.g. water in discarded tyres, open coconuts or in the collection bowls under flower pots). The relatively low permeabilities of St. Lucian soils (particularly the montmorillonite soils in the drier areas) mean that in the wet seasons even upland areas may harbour mosquito breeding grounds, and these areas commonly surround the major population centres.

Sandflies, which breed in very wet soil or shallow mud are likewise common in these coastal areas. They may spread a number of fevers, although in St Lucia these are apparently somewhat uncommon. However, they commonly induce very unpleasant allergic reactions in many individuals.

Bilharzia has also been present in St Lucia and the Consultants were warned by local people in one particular area that stagnant water may still harbour the parasites.

Successful watershed management would tackle the problem of breeding grounds for these disease vectors, particularly the clean up of any plastic waste and broken coconuts which would breed the dengue mosquitoes.

4.6 PLANNING ISSUES: CONFLICTING DEMANDS FROM DIFFERENT SECTORS

A successful watershed and environmental management programme over the whole island must be aware of the conflicting demands on land and water from different sectors. A summary of this situation as follows:

4.6.1 Nature Protection

This must be afforded the highest priority, both for the protection of habitats for the endangered and endemic species, and for protection of the soil and water resources in the central mountainous area of the island: the latter is particularly important for dry season baseflow. Any failings in this area is likely to have very large negative effects on the rest of the economy: dry season water supplies would be negatively impacted, as would the tourism industry, affected particularly by silt and rubbish in the coastal areas and damage to the marine and terrestrial environments. Greater attention to nature protection is likely to attract more tourists as well as obtain a good name for the island in the eyes of the international conservation movement (cf Costa Rica).

Protection of the Forest Reserves is in the hands of the Forest Department, but much forest land is in private hands. Where this private land is in the steep, high-rainfall central part of the island, every incentive must be given to the land owners **not** to develop their holdings to agriculture. The biggest incentive would be for the government **not** to finance any feeder roads in these areas. Another incentive could be for owners to be able to receive income tax rebates for steep land kept under forestry.

Private scrub forest land (coastal areas) may be of great value for protection of endangered species (particularly in NE of the island) or may be of relatively little value (areas near Castries, e.g. to the north of Ciceron). Studies need to be undertaken to zone these areas. Again provision (or non-provision) of infrastructure will determine whether the areas will be used or alternately encroached upon.

4.6.2 Tourism

Tourism is highly concentrated, mainly in the NW part of the island, but with smaller developments at Marigot Bay, the Soufriere area, and the Vieux Fort area. This makes conflicts of land use somewhat easier to resolve. Attention to the northern watersheds (particularly Choc and Castries and Cul de Sac) is likely to improve coastal water quality significantly for 80% of the tourist areas. However, development of tourism has meant that land values have risen enormously with the result that much of this area is held by land speculators and is lying idle. Appropriate land taxation would be the best mechanism to get this land into production and to generate revenue for government.

A further problem in the 'tourism - residential belt' is the introduction of light industry and commercial premises without controls on architectural quality and landscaping. Stricter zoning in this area is required. Also much could be done in the way of roadside tree planting and beautification. Industry and commerce should ideally be zoned for other areas, both to relieve pressure on this belt and to create employment elsewhere.

Tourism in other areas has to co-exist on a more even footing with other sectors of the economy.

4.6.3 Agriculture

The problems of agriculture have been discussed in detail elsewhere. These include problems of banana monoculture, erosion and run-off, worsening flooding in bottomland areas, and encroachment into steep forest areas.

There is a very urgent need to stop any further land clearing in steep upland areas. This should be firstly tackled by stopping cultivation above WASA intakes, and by imposing slope limits on

cultivation of new land. A complete ban on new feeder roads should be imposed and no funds should be spent on feeder roads serving excessively steep areas.

Ideally smallholders should be able to cultivate annual crops in less steeply sloping areas. Underutilised lands of less than 10 degrees slope need to be investigated for inclusion into a land bank for such a purpose. This would then relieve pressure to some extent on the steeply sloping land.

4.6.4 Industry

In a St Lucian context industry should be zoned to create employment and to minimise negative impacts with tourism, residential and agricultural areas. Inappropriate zoning of flat land with a high flood risk has been seen in several areas, the most notable being the lower floodplain of the Cul de Sac. In these areas, a 1 in 5 to 1 in 10 year risk of flooding would be acceptable for seasonal cropping (5-10% of crops being damaged) but this would be unacceptable for building. A further building problem in the flat land is inadequate subsoil materials for foundations.

The policy of moving light industry to the people, rather than people to industry, is to be supported where the people are living in areas of no risk of flooding or landslides, and in general most areas in the Em and Dm agroecological zones show relatively low risks. However, in some upper watersheds a large proportion of the people may be in risk areas, and this is particularly true for the Chopin Ridge-Ravine Poisson areas. In these areas both Government and the private sector should be wary of siting employment-generating enterprises.

Ideally shallow soil areas in gently sloping upland areas, particularly in agro-ecological zones Em and Fm would be more appropriate for building. Although surface materials are of montmorillonite clay, these can be removed exposing much better materials for foundations.

4.6.5 Residential Areas

The same comments on building in floodplain areas also apply for residential land uses, with many houses having been flooded in the TSD and 26th October 1996 events.

Building in landslide-risk areas has also occurred in many areas, the sites being susceptible either to land movement or to burial by mudflow materials. In general, land which is on, or immediately below, slopes of 25 degrees or more is at risk: that over 30 degrees represents a high risk. In the Chopin Ridge / Ravine Poisson areas, perhaps as many as 60% of the houses are in landslide risk areas, with about 30% in areas of high landslide risk. Although immediate resettlement of these people is not realistic, any further building needs to be controlled very vigorously.

Large areas of land of shallow soils in gently-sloping upland areas (Agro-ecological Zones Dm and Em) could increasingly be used for residential purposes. However, for home gardens in these areas soil depth is a limiting factor. Increasing soil depth both by local bulldozing and landscaping would be valuable (topsoils of montmorillonite materials have to be removed from the building site, and this can be used to increase soil depth in the garden areas). Similarly depositing spoil materials from river beds etc into these areas would be beneficial.

4.6.6 Infrastructure

Although government may have relatively little control over private lands, it closely controls infrastructure, notably roads and drainage. This infrastructure in turn has a large affect on developments on the adjacent private lands. Both new road developments and repairs to existing roads will increase intensity of land use in the adjacent areas. In the past it is clear that these have not been subject to an EIA process, and gross mistakes have been made. It is important that these are not

repeated in the future, and it is most important that any international money is not seen to be supporting developments which are causing massive environmental damage such as is seen in Figure 4.4.

4.7 ENVIRONMENTAL IMPACT OF PHASE 1 CIVIL ENGINEERING WORKS

4.7.1 Description of the Phase 1 Works and Initial Environmental Considerations

Phase 1 works are described in detail from an engineering and hydrological viewpoint in the River Engineering & Hydrometeorology section of the Interim Report. Table 4.15 summarises the main features of these works, including their division into some 26 contracts (listed as A to Z, excluding O but including AA). For comparison, original estimates (Report dated Dec. 1994) and final sums allocated for the works are given in adjacent columns, and some further explanation on what was involved in the works is given in a remarks column.

The large difference in the original and final estimates can be explained by:

- a) much more extensive gabion walls were finally constructed in three of the lower river systems, mainly for protection of urban areas, comprising Soufriere, involving an extra EC\$1.6m; Canaries, an extra \$1m, and Anse la Raye, an extra \$0.45m;
- b) major rip-rap protection for Dennery town (extra \$0.96m);
- c) more extensive re-sectioning and loop-cutting in four of the rivers (Cul de Sac, extra \$1.5m; Roseau, extra \$1.7m; Mabouya, extra \$0.68m, Troumassee, extra \$0.34m);
- d) new identified works at Vieux Fort and Choiseul (extra \$0.23m).

Comparisons of costs and benefits represented by the works are outside the scope of this analysis. However, it should be appreciated that items a), b), and d) are essentially for protection of urban areas and vital infrastructure, while item c), involving an extra \$4.2m, was undertaken mainly for the protection of agricultural land.

4.7.2 Method of Assessment

The current assessment comprised the following stages:

- i. Reconnaissance visit to the most important parts of all 26 schemes. This was undertaken during different periods in October and November 1996, and in June and July, 1997, accompanying both local Ministry engineers and the Consultant's engineering staff.
- ii. Inspection of available detailed plans. A rapid inspection was made on all available plans, and more detailed assessment was made on three of the valleys where most disruptive work was undertaken (Cul de Sac, Roseau and Mabouya). In addition Troumassee valley was quickly inspected, with a closer inspection being given to the loop-cutting undertaken in the area below the main road bridge. Table 2.2 (3 pages) of Annex 8 gives major features of the plans for these three valleys.
- iii. Listing of the major measures undertaken and identification of major issues applying to these measures (screening & scoping)

TABLE 4.15: PHASE 1: PRIORITY WORKS

Cont- -ract	Watershed/River Location	Reach	Approximate Dimensions (m) L D	Form of Works	Unit Rate EC\$/km _(Dec'94 Rprt)_(Apr96)	Total EC\$M	Actual EC\$M	Remarks
RIVER WORKS								
A	Souffriere	a. Main channel	Mouth to 2km	Desilting, river training bank stabilisation	1,000,000	2,000	3,550	Major gabion walls protecting urban infrastructure
B	Cul de Sac	a. Main channel	Mouth to slope control weir #1	Desilting	50,000	0.050	0.000	}
C		b. Odsan Ravine	Confluence to Odsan Bridge	Desilting	18,000	0.054	0.011	}Included major loop - cutting
D		c. Desglos Ravine	From confluence to 1km u/s	Desilting	18,000	0.054	0.051	}channel re-alignment and
E		d. Ravine Souffre	Confluence to R Elibox lands	Desilting & bank stabilisation	52,100	0.104	0.031	}re-sectioning. Some gabion
F			Taraprasad Br. to Rav. Roches	Right bank stabilisation	50,000	0.050	0.056	}walls & rip - rap protn continuing
G		e. Main channel	Odsan Bridge to L'Abbaye	Desilting, resectioning	70,000	0.560	2,134	}
H	Roseau	a. Main channel	Mouth to 1.5km u/s??6KM??	Desilting, mouth breaching	20,000	0.030	2,100	}Included major loop - cutting
I		b. Main channel	Roseau bridge to 200m u/s	Debris clearance		0.004	0.008	}channel realignment/resectioning.
J	Canaries	a. Main channel	Mouth to 4km upstream	Desilting Bank stabilisation	50,000 300,000	0.200 0.150	1,365	}Incl.gabions & masonry walls }protecting town infrastructure
K	Anse la Rayea	a. Main channel	West coast Road to bridge	Bank stabilisation	400,000	0.080	0,534	Incl.gabions & masonry walls
L	Fond	a. Main channel	Mouth to 2km u/s	Debris clearance, desilting	41,000	0.082	0,100	Some gabion protection to town
M	Dennerly	a. Main channel	Mouth to East Coast Bridge	Desilting, river training	500,000	0,500	1,462	Major rip - rap protectn to town
N	Canelles	a. Main channel	Mouth to East Coast Bridge	Desilting, mouth breaching	25,000	0,035	0,100	}De-silting & debris clearance
P		b. Main channel	EC Bridge to sugar mills	Desilting, bank stabilisation	41,000	0,025	0,046	}
R	Mabouya	a. Tributary	Grand Riviere bridges & u/s	Desilting	50,000	0,060	0,741	}Included major loop - cutting, }channel realignment/resectioning.
S	Troumassee	a. Main channel	Beauchamp to Moreau, 4km	Resectioning, lower & upper	80,000	0,160	0,500	}Included major loop - cutting, }channel realignment/resectioning.
DRAINAGE WORKS								
T	Roseau	a. Morne d'Or	Outfall u/s for 1km	Debris clearance & desilting	46,500	0,047	0,018	
U		b. Belair Mains	3km main drainage outlets	Desilting	46,500	0,070	0,007	
V		c. Roseau Mtn.d'Or	Road drain for agriculture	Desilting	31,000	0,047		
W		d. Hollywd - Jacmel	Roseau Jacmel	Desilting	46,500	0,051	0,002	
X	1 Fond d'Or	a. Den'ry - Farmco	Interceptor drainage channels	Debris clearance & desilting	18,000	0,108	0,042	
			5,000 0.6 to 1	Desilting	18,000	0,090		
OTHER								
Y	Vieux Fort	} New identified works					0,084	
Z	Choiseul	}					0,150	
TOTAL COSTS:						4.61	13.09	

- iv. Detailed field inspection of the major and most controversial areas which comprised the Cul de Sac, Roseau and Mabouya Valleys, where major re-sectioning and loop-cutting operations have been undertaken. Field inspection included walking along riverbanks through most of the valleys, inspection of crops, groundcover, soil surfaces and materials and current sources of erosion. All local farmers encountered were consulted regarding extent of damage during TSD, extent of flooding during 26 October and 11 November 1996, effect of the works on their land, and their opinion on the effectiveness of the works. River mouth areas and adjacent beaches were also visited to see if actions upstream had adversely impacted on those areas.

4.7.3 Results of the Assessment

Comments on the detailed plans (covering the 3 major valleys) are given in Table 2.2 of Annex 8. Any special comment on the plans with respect to environmental considerations is given in a separate column, while comment on the situation as observed in the field (July, 1997) is given in the last column.

The Environmental Evaluation for the Phase 1 works programme is given in Table 4.16 under the 12 main groupings of work measures undertaken. In addition to this tabular data further important information, including external factors, were noted, these being described in Annex 8.

4.7.4 Conclusions of Phase 1 Works & Lessons for Future Events

- a) General By necessity Phase 1 planning and implementation was undertaken in a hurry, and time did not permit environmental assessments of specific detailed plans. Although environmental lessons have now been learnt from both planning and implementation stages of the work, the Phase 1 engineers should be complimented in doing much accurate work in a short period of time at the planning stage for a high proportion of the work undertaken. All should now learn the environmental lessons coming out of the Phase 1 works and change a number of items in any future work.
- b) The Format of many of the Phase 1 detailed plans (1:1000 scale) is good, with existing riverbanks, areas/features of flood damage, existing trees, and recommendations for remedial works required being clearly shown. Widening of river channels was correctly specified to occur only on the inside of river bends, with the maximum of bankside vegetation retained on the eroding outside bend. A few of the plans very usefully showed location of landholdings, name, and even phone numbers of the owners. This format should be repeated in any future series of works, but with additions and modifications as shown in items c) - j) below.
- c) Planting of bankside trees should be specified as a top priority, a double row of trees on each bank being required. Tree seedlings should be provided by government, together with instructions on planting and maintenance (fertilising and spot weeding in the initial 2-3 years). A wide range of species should be made available, with final selection to be made by the landowner. Planting of grasses, which was specified in many of the plans, and also implemented in most cases, is not sufficient alone to stabilise banks below 1m depth. Maintenance of trees should be the responsibility of the landowner, who should obtain any produce from the trees.

TABLE 4.16: ENVIRONMENTAL EVALUATION, PHASE I WORKS PROGRAMME

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Measure Undertaken	Status of Operation	Observed Impact			Comments & Lessons for Future Events
		Parameter	Size	Major effect	
1) Clearance of loose debris (organic & rubbish)	Undertaken for 10 Rivers, usually combined with measures 2 & 3, below.	i) Removal of blockage	+++ +++ +++ +/-	Less risk of collapsed infrastr. Decreased floodplain flooding Decreased WTs in adjac. land Increased channel flow rate	Non-controversial. Debris to be removed to rubbish dump. Any decomposable rubbish can be used as compost / mulch on adjacent land, although separation from non-decomposables time-consuming. Dead animals, etc to be buried.
		ii) Removal of org. mat.	+++	Less eutrophication, health hazard	
2) Removal of Sediment to original channel bed level within original channel (de-silting)	Undertaken for 9 rivers, often in association with other activities	i) Removal of blockage	+++ +++ +++ +/-	Less risk of collapsed infrastr. Decreased floodplain flooding Decreased WTs in adjacent land Increased channel flow rate	Non-controversial. Fine-textured sediment to be used for partial, but even, infilling of meander loops, and for increasing depth of shallow soil areas in nearby sloping land.
3) Resectioning: A: Widening of existing channel, smoothing channel sides, & some grading	Major work on 5 rivers: Cul de Sac, Roseau, Mabouya, Troumassee, Soufriere	i) Removal of riverbank material	+++ -- -- --	(all of above effects, plus:) Current loss of agric. land Future threats to agric land Loss of riverbank habitats	Overall beneficial, but some problems: a) needs to be combined with Measures 9 and esp. 10 b) fine-textured sediment to be used as above c) level of detailed planning, consultation & compensation needs improvement, d) effect downstream needs consideration.
4) Resectioning: B: Deepening existing channel below original bed level	Significant work on 5 major rivers (as above)	i) Removal of riverbed material/deepening ii) Increased erosivity of existing channel iii) increased erosivity of tributary channels	++/- --- ---	(all of above effects, as in 3), plus: Aggravated bank erosion, undercutting below rooting depths Aggravated erosion in tributaries	Overall problematic, & likely to create more problems than it solves. Deepening of channel should be undertaken only to original elevation of former channel.
5) Rock protection (Rip-rap) along base of eroding channel bank: Directly Protecting Infrastructure	Undertaken on all 10 rivers: major work at Denney,	i) prevention of river bank erosion ii) possible movement during high flows	+++ --	Partial protection of eroding bank Movement causing channel obstruction and bank scouring	Overall beneficial, but gabion baskets much more effective, although much more expensive.
6) Rock protection (above) Mainly protecting Agricultural Land	Undertaken on all 10 rivers	(as above)		(as above)	Expensive in relation to benefits
7) Gabion Baskets along eroding channel bank: Directly Protecting Infrastructure	Major works in most rivers: heavy investment in Soufriere, Anse la Raye, Cul de Sac, Canaries,	i) prevention of river bank erosion ii) interstitial spaces within basket iii) appearance	+++ +++ ++ --	V. good protection of eroding bank Provision of shelter for riverine fauna. Permeable to tree roots Initially unsightly	Very expensive (c. EC\$200/m2), but justified for protection of essential infrastructure. Should be combined with permeable/ root penetrable filter blanket and planting of tree vegetation on adjacent land.
8) Gabion Baskets along eroding channel bank: Mainly protecting Agricultural Land	Undertaken in a few rivers only.	(as above)		(as above)	High cost not justified in most cases.
9) Planting cover crops/ grasses on river banks (vetiver, Roseau grass)	Mentioned in many (but not all) plans, c. 80% undertaken.	Est. of groundcover Est. of dense rooting Provision of fodder Lack of taproots	+++ +++ +/- ---	Prevention of raindrop impact Stabilisation of surface soil Cattle may trample bank Soil below 1m not stabilised	Effective in surface soil stabilisation, but not as effective for long-term river bank stabilisation as planting of trees. Should thus be combined with tree planting. Vetiver preferable to Roseau.
10) Planting trees along river banks	Not emphasised sufficiently in Ph1: only c10% planted.	Est. of deep root syst. Est. of litter layer Shading of undergrowth Shading of adj. crops	+++ +++ +/- --	Prevention of slumping Increased raindrop protection increased infiltration Change of species Loss of crop income	Overall highly beneficial: double row of trees needs to be established on both banks, and maintained by land owners. Large number of species are possible, bringing med. & long-term income to farmers. Needs much more promotion.
11) Meander (Loop)-Cutting	Major work on 3 rivs. (Roseau-2130m Mabouya-1450m Cul de Sac-1250m) Smaller work on Troumassee.	Imprvmt. in drainability ii) Increased erosivity Removal of trees/vegtn Large vol. of spoil Loss of agric. land Loss of access to cut-off land	+++ --- --- --- --- ---	Increased speed of drainage Aggravated bank erosion Loss of habitat, income. Further silting of river channels Need for compensatn to Indowner Need for compensatn to Indowner	Overall highly problematic: not recommended for any future programmes. Many land disputes / compensation claims outstanding. Increased flow rates of river may aggravate bank erosion during future floods, and increase claims from other landowners.
12) Infilling old meanders	Major work on 3 rivs. (Roseau-2130m Mabouya-1450m Cul de Sac-1250m) Smaller work on Troumassee.	Creation of new land Est. of some infill areas Est. of infilled areas Lower infilling elev	-- --- +++ ++ ---	Legal status of new land Texture, fertility of new land Estab. of some new agric land. Estab. of new agric land. Overspill flood channel Flood hazard for most crops	Any benefits from new land creation have been fairly small due to clouded legal status, and quality of new land (texture of soil, fertility, evenness of surface, flood hazard).
-partial filling, upstream side only					
-partial but even filling					Partial, but even filling, has been more successful than filling of upstream part of loop only. Old loop then serves as reserve flood channel.

- d) Planting of grasses or leguminous cover crops should be undertaken on bare landsurfaces together with the above trees. For planting on exposed subsoil material, small NPK fertiliser applications should be made at the time of planting. Grasses and cover crops will be effective in the first few years in reducing soil erosion, but will eventually be largely shaded out by the more effective perennial trees. Vetiver (khus-khus) grass is a preferred species because it is not palatable and it has low maintenance requirements as well as being short (and therefore obstructing river flow to a lower extent than, for example, Roseau Grass). Cattle should be kept well away from river banks.
- e) Making graded river embankments of unconsolidated transported material is likely to prove a failure, particularly where the embankments are more than 3m in height and not stabilised quickly by perennial, deep-rooting vegetation.
- f) Deepening of river channels below original levels is likewise likely to lead to increased problems of riverbank erosion. Any future cleaning of river channels should only be undertaken to original bed levels.
- g) Any future meander (loop)-cutting should not be undertaken, except in exceptional circumstances (e.g. where current meanders are threatening major infrastructure over a wide area). In these exceptional circumstances the following conditions should apply:
- names and contact phone nos/addresses of landowners should be given on the plans, and inset boxes drawn showing details and dates of compensation, land exchanges, and conditions of land uses being accepted by the respective landowners. Access to cut-off land and possible compensation claims by owners losing land due to future erosion should be considered carefully.
 - soil from new cuts should partly infill the old meanders to an even but lower elevation, in order both to make a secondary flood channel and to create new agricultural land, compensating for the loss of land represented by the loop cut. Topsoil (0-30cm) from the cut should be stored to one side, and finally positioned as topsoil for the infilled meander. Sandy materials should be avoided for the surface 30cm of these infill areas.
 - weir structures may have to be constructed in cut off sections to slow the flow of water and reduce risk of increased bank erosion.
- h) Gabion baskets are highly effective in reducing bank erosion, but should only be used for protection of urban areas and essential infrastructure. (Gabion baskets are too expensive to be considered for protecting agricultural land.) Gabions should further be stabilised by placement of permeable membranes, and adjacent bank areas should be planted to trees. Gabions are generally favourable environmentally, providing habitats for fish and small aquatic animals and although somewhat unsightly, they are generally rapidly vegetated (vines, creepers, eventually shrubs and trees).
- i) Heightening of banks in the lowermost parts of each valley reduces silt deposition in the floodplains, backswamps and wetland forest areas (including mangroves). Increased amounts of silt are then deposited in the sea. The lowermost part of floodplains should thus be kept under natural vegetation or rough grazing and allowed to flood. Further encroachment of these areas should not be allowed to occur, and likewise further raising of river banks/bunds in these areas should not be undertaken.
- j) Although the above measures may be essential, contributory causes to peak flooding events should be appreciated. Major improvements can be made by better soil conservation measures, notably trash management in bananas, and by major planting programmes for perennial trees in place of both bananas and annual crops on sloping land, particularly that over 25 degrees.

4.8 POTENTIAL ENVIRONMENTAL ISSUES, PHASE 2 PROPOSALS

4.8.1 Description of Measures Proposed

Phase 2 proposals in nearly all cases are fundamentally different from the Phase 1 Priority Works in that they are centred on long-term measures to improve watershed management and particularly soil and water conservation. They inherently thus should involve most of the farmers in the island, and most of the implementation work will have to be done by the farmers themselves, with government officers providing advice, possibly undertaking local planning, and probably assisting in provision of any materials required. Most of the Phase 2 proposals are currently under trial and thus these assessments (July, revised November, 1997) are somewhat tentative.

Phase 2 measures proposed include:

- Banana trash management on sloping land:
 - maintenance of uniform trash cover, with trash aligned on contour;
 - trash lines on contour, held by closely-spaced short stakes;
- Banana trash management on flat land served with deep surface drains
 - trash lines towards base of surface drain
- Tied contour drains on sloping land;
- Stone-lined stepped drains, gully plugs and check dams;
- Retention/establishment of a 10m-wide river reserve, planted to trees.

In addition changes of land use are advocated, including:

- planting of very steep land to perennial tree cover, preferably long-cycle forest plantations;
- gradual replacement bananas on very steep land with perennial fruit trees, probably mangos, breadfruit, avocados, citrus;
- banning of seasonal cultivation on steep slopes.

4.8.2 Method of Assessment

Observations and measurements are currently underway on trials being undertaken. In addition these include discussion with the local farmers on whose land the trials are being undertaken, some neighbouring farmers, agricultural officers, and research officers of the MAFF&E and WIBDECO. Research reports relating to crops affected were also studied. For the banana trash trials, four sites were investigated (see Annex 7). Observations and recordings were made at the start of the trials (Nov.96), during the end of the Dry Season (June/July,97), and final observations were made during the peak of the second Wet Season (Sept-November,97).

For each proposed measure, a long-list of parameters which might be affected was devised, and the major effect on each and the relative size of impact was assessed. A +++rating denoted a large beneficial impact; a --- rating conversely signified a large negative impact, and a +/- denoted both beneficial and negative impacts. Parameters were then indexed according to size of impact, from very positive to very negative. Any applicable mitigating measures, to be employed against negative impacts, were then listed.

The status of the recommendation, the cost per acre and the area (or distance) over which the measure should be implemented, were listed for each of the proposed measures.

4.8.3 Results of Assessment

Results of the assessment are tabulated in **Table 4.17**.

4.8.4 Conclusions on the Phase 2 Proposals

- a) Maintaining a uniform trash cover in banana fields will have a very large positive effect in reducing run-off and surface wash erosion. Experimental data suggests that infiltration rates are increased by a factor of 3 by this trash cover over bare soil surfaces in both wet and dry seasons. The large increase in porosity under the trash is caused both by denser banana rooting extending to the mineral soil surface, and by much increased soil animal (particularly earthworm) activity. Infiltration over 30mins averaged 52mm in the wet season and 94mm in the dry season, as compared to 18 and 34 mm respectively for bare soil surfaces.
- b) The cost of setting up and maintaining this trash cover is minimal, totalling 4 mandays and 3 mandays/acre/year respectively, valued at EC\$120 and \$90 respectively at current labour rates. All materials are produced in situ in the field, and no extra material costs are involved.
- c) Increased rooting volumes, more efficient nutrient recycling, increased ecosystem buffering, much improved weed control, improved incorporation of fertilizer and lime, and an increased retention of soil water are all positive impacts of this recommended measure which benefit the area receiving the trash. Release of the infiltrated water over a longer time period will entail less sharp peaks of river flows, and release as cleaner water, with lower contents of suspended sediments. These parameters will benefit downstream areas.
- d) Some possible negative impacts have been noted and are continued to be monitored. These include problems with nematicide spraying, possibly increase in borer attacks, difficulty in walking over fields in wet weather, possible increase in snake population, and an observed big increase in snail populations. However mitigating measures for all of these negative impacts are suggested.
- e) In addition to maintenance of uniform trash cover installation of trash lines is also recommended, particularly for steeper slopes and in fields where trash production is heavy. These trash lines have further positive impacts - in addition to those listed in para 3 above - in that retention of soil materials and trash itself on slopes is improved. Where stakes are of glyricidia, further loppings of fresh leaves will add symbiotically-fixed nitrogen to the soil. No additional negative impacts are observed with trash lines.
- f) Tied contour drains have further benefits if properly constructed and maintained. Further eroded soil would be retained on the contour, but this material should periodically be cleaned out. Water would also be retained on the contour, which would be doubly beneficial during the periods where potential evapotranspiration exceeds rainfall (Jan-June for many areas - see Section 2 of Interim Environmental Report). However these drains show a number of disadvantages:
 - for landslide risk areas (slopes >30 degrees, more concave topography) risk of landslides would increase unless ties in the drains are managed very carefully;
 - during wet seasons drains serve to improve both surface and subsurface drainage - increased WTs, albeit of short duration, will have an adverse effect on yields;
 - cost of drains is relatively high (10-30mandays/acre for installation, 4-8md for maintenance).
- g) Establishment and retention of a 10m-wide river reserve (double rows of trees on either bank) will have a large and favourable effect on stabilising riverbanks. Further positive impacts include provision of a buffer for deposition of coarse sediment from the river (as well as any trash), a buffer for intrusion of fertiliser nutrients and pesticides, and a habitat for wildlife. A very wide range of species are suitable for this riverbank planting, which ideally should be undertaken on a 8x8 ft spacing.

TABLE 4.17: POTENTIAL ENVIRONMENTAL ISSUES, PHASE II PROPOSALS

Proposed Measure	Status of Recommendation	Cost of Recommendation	Approx. Area (ac) or Distance (km)	Parameter	Possible Impact Size	Major effect	Mitigating measures (for negative impacts)
Banana trash management: 1) uniform trash, aligned on contour	Recommended by WINBAN/WIBDECO (Manual, p2-3). Implemented on steep land by best farmers. Needs major promotion by agric. extension officers & WMAFs. Farmers to supply labour: trash materials supplied in situ (plus some trash from nearby alluvial & colluvial banana areas?)	Approx. 4 extra man-days/acre to set up, thereafter 3 man-days/acre/yr to maintain (in addition to routine detashing) (ie 7 days in year 1 - or EC\$210/acre; 3 days in Yr2 etc or EC\$90/acre)	All land > 5deg (c12,000ac)	i) Infiltration/runoff	+++	Infiltration rates increased 3x: run-off & erosion markedly decreased; nutrients retained in soil	
				ii) Nutrient recycling	+++	Uniform, more efficient	
				iii) Soil Ecology	++	Increased ecosystem buffering - reduced soil pathogens	
				iv) Rooting volume	++	Banana rooting to surface	
				v) Weed control	++	Much improved weed control	
				vi) Lime application	-	Adversely affecting broadcasting	Broadcast lime before trash application
				vii) Fertiliser applicn	++	May adversely affect b'casting Lower losses thru run-off	Apply in semi-circ. above mat. within 1.5ft radius.
				viii) Leafspot control	-/+	Increase in humidity & retention of possible diseased leaves	Maintain uniform thin trash cover, should dry v. quickly, not increasing air humidity
				ix) Nematode control	-	Problems w nematode spraying	Maintain 1 - 1.5ft radius trash-free
				x) Borer control	-	Cut pseudostems attract borers	Pseudostems to be cut into strips to dry out quickly, then to be used mainly in trash lines.
				xi) Trafficability	-	Difficulty in walking/slipping in wet weather	Pseudostems to be cut into strips and used in trash lines.
				xii) Blocking drainage lines	-	Washing into drainage lines	Trash cover to be used also with trash lines
				xiii) Snakes	-	Possible increase in population	Workers to wear boots
				xiv) Snails & slugs	-	Big increase in population	Monitoring wr to population and damage: use of methiodide, slugit, or methiocarb if necessary
2) trash lines	Recommended by WINBAN/WIBDECO (Manual, p2-3). Implemented on steep land by some of the best farmers. Needs major promotion by agric. extension officers & WMAFs. Farmers to supply labour: trash materials supplied in situ (plus some trash from colluv. & alluv. areas?) Supply of stakes to be organised by agric. extension officers & WMAFs?	Approx. 4 extra man-days/acre to set up, thereafter 3 man-days/acre/yr to maintain (in addition to routine detashing) (ie 7 days in year 1 - or EC\$210/acre; 3 days in Yr2 etc or EC\$90/acre)	All land > 5deg (c12,000ac)	as above, i-x, and xiii-xiv, but localised along contour lines			
				i) Retn. eroded soil	+++	Retention of soil materials	
				ii) Net nutrient increase	+++	N-fixation by glycidia stakes	
				iii) Retn. trash material	++	Retention of trash materials debris, etc	

TABLE 4.17 (CONT): POTENTIAL ENVIRONMENTAL ISSUES, PHASE II PROPOSALS

Proposed Measure	Status of Recommendation	Cost of Recommendation	Approx. Area (ac) or Distance (km)	Parameter	Possible Impact Size	Major effect	Mitigating measures (for negative impacts)
3) Tied contour drains	Recommended by WINBAN/WBDECO (Manual, p1-2). Implemented on steep land by many of the better farmers, but design of drains could be improved in most cases. Ties/dams to be kept open in wet season, closed in dry season to retain water.	Expensive. 150-300m drains required /acre, c.10-30mandays to install, 4-8mandays /yr to maintain. (Begin with coarse spacing, increase density if required) Total cost: EC\$300-1000 for installation, c.\$150-300/acre for maintenance. AESD & extension staff to promote & assist in field design.	All banana land, ie. 19,000ac.	i) Dry Season Runoff Control ii) Wet Season Runoff Control iii) Wet Season Water Retention	+++ +++ --	Retention of water & silt on slope - Increased water avail. in Dry Seas. - much increased nutrient retentn. Retention of most of silt on slope; slowing rate of drainage/runoff Retention of some water on slope; a) increasing landslide risk in some areas of >30deg slope b) breeding ground for mosquitoes	Reduce height of ties/check - dams in Wet Season, especially for steeper land. Design drains to deflect water away from high landslide - risk areas. Keep trash out of drains - desilt frequently
4) Stone-lined, stepped drains; gully plugs & check dams.	Designs given in Engin - eering Interim Report. (Also recommended in WINBAN Manual, but no details given.)	Very expensive, both in labour and materials. Approx 10-20 man - days/100m drain, ie. EC\$350-700 plus \$350-700 for materials.	Most threatened areas only:	Prevention of gulleys	+++		
5) Retention of 10m River Reserve	Legislation, but not enforced; frequent annual crop cultivation occurs to edge of river. Forest Dept & AESD active in planting river banks. Double rows of deep rooting trees on 4x8m spacing recom - mended, thinned to 8x8m after 5 years.	Cost of planting & establishment over 3 years c. EC\$300/100m. Bananas can be retained to give partial shade for first 3 years.	Lower parts of all 20 major rivers: c. 200km total, 100km requiring major attention.	i) Riverbank stabilisation ii) Provision of habitat iii) Buffer for sedimentation iv) Buffer for fertilizers & pesticides iv) Fallen trees & branches v) Loss of income	+++ ++ ++ ++ -- --	Prevention of rapid erosion of riverbanks. Habitat for animals, birds. Habitat also for some crop pests, & harmful animals. Riverbank buffer for deposition of coarse sediment from river. Intrusion of fertiliser nutrients & pesticides minimised by buffer. Problem of fallen trees blocking bridges culverts etc Loss of income due to planting of less profitable crop;	Some trimming of tree branches & unstable trees may be required. Bananas to be grown as shade crop for initial 3 years; efforts on marketing req for alternative crops & products.

4.9 PRESCRIPTIONS FOR IMPROVED WATERSHED & ENVIRONMENTAL MANAGEMENT: SUMMARY AND CONCLUSIONS

4.9.1 Agricultural Land, Production, and Practices

a) Major emphasis must be placed on soil conservation, particularly in banana lands. This emphasis should include:

- optimal trash management to protect entire soil surfaces;
- stakes closely spaced on contour to retain trash (trash-lines);
- tied contour drains (careful management required on steeper slopes and landslide-risk areas);
- better design of vertical drains, with bio-engineered controls;
- integration of drainage from paths and tracks, with field drainage.

Work on the banana land should be the responsibility of the SLBGA staff, and criteria for certification of sloping land should include trash management. Any future project would seek to finance up to 5 SLBGA officers to work full time on soil conservation extension and certification. This would be through a grant to the SLBGA from the LCB who would monitor progress of soil conservation improvements.

It is reassuring that the Banana Certification Programme by WIBDECO/SLBGA is proceeding at a promising pace, and could in the near future be used as the major mechanism for improving soil conservation on steeply sloping banana lands.

The existing MAFF&E Extension Service would undertake soil conservation extension work on other crops.

b) Encouragement should be given to farmers to re-plant banana areas to permanent treecrops in sensitive areas, vis

- at ridgetops, and within 100m of ridgetops,
- on land of >30 degrees slope,
- on landslide-risk areas, irrespective of slope.

On steep slopes, planting of some permanent treecrops within existing bananas should be encouraged, leading to gradual replacement of some bananas by treecrops. Top priority should be given to banana land of over 30 degrees slope, comprising some 1900 acres(760ha), followed by land of 25-30 degrees slope (2500 acres - 1000ha). Any future project should make planting material available to farmers, together with fertiliser inputs and technical advice. To compensate for loss of income in years 2-5 farmers would be encouraged to take loans through the local credit unions, to whom the project would extend soft loan money on a revolving basis. Alternative crops to be immediately promoted would include Julie Mango, Breadfruit, Avocado, Sweet Orange and Cocoa.

c) Prohibition of clearing of new agricultural holdings on forest land should be enforced, particularly in the following cases:

- at ridgetops, and within 100m of ridgetops;
- on land of >30 degrees slope;
- on landslide risk areas, irrespective of slope.

Prohibition should be backed up by public education, involving the media, the agricultural extension service, schools, churches, police, and co-ordinated through the local WMAFs.

- d) Felling of any perennial trees on slopes of >25 degrees should be prohibited, these trees being the best guarantee that the land on which they stand will not be subject to landslides.
- e) Bans should be enforced on the cultivation of land above WASA water intakes.
- f) A major effort should go into coordination of marketing of treecrop products, using
 - existing banana boat transport and marketing channels in the UK;
 - inter-island trade (particularly to Barbados & Trinidad);
 - air freight, particularly to the UK, Canada, and Europe.
 - local tourist hotels, cruise ship and yacht suppliers.

MAFF&E would be strengthened to improve publicity and information services. Produce would include commonly exported produce such as mangoes, avocados, bread-fruit, guava, golden apple, cashew, soursop and trials would be undertaken on new treecrops.

- g) Some alluvial lowlands, particularly in the most flood-prone areas, could be considered for alternative seasonal crops, or crops more tolerant of flooding or waterlogging, e.g. dasheen.
- h) Under-utilised lands of less than 10-15 degrees slope should be available for agricultural use by suitable landless smallholders. The Land Taxation mechanism could be employed to encourage land owners to use such land to full potential. A Land Bank Programme should be considered to facilitate agricultural use of such land.
- i) The decline in the coconut industry, and the current felling of coconut trees, gives major cause for concern. Coconut trees are extremely useful in binding the soil in many banana plantations. A major marketing effort is required so that the decline in this important, and eco-friendly crop, is reversed. The recent re-opening of Soufriere factory is to be welcomed, and it is in everyone's interest that repurchasing of coconuts is resumed.

4.9.2 Forestry

- a) Forest buffer zones should be extended into existing agricultural areas in landslide-risk areas.
- b) The 20-metre river reserve should be rigorously enforced. Mixed perennial treecrops and some timber species should be encouraged. Radical pruning of older trees should be discouraged.
- c) The excellent work of the Forestry Department in education and public awareness should be further encouraged, including the introduction and planting of a wider range of forest species, both indigenous and exotics. The Jak-fruit (*Artocarpus heterophyllus*) deserves promotion, as this is useful as a fruit, a vegetable, and is an excellent timber tree.

4.9.3 Landslide-Risk, and Flood-Risk Areas and Zonation

a) Landslide Risk

- i) A major emphasis on public education should be targeted for the worst landslide-risk areas (e.g. Ravine Poisson), and the highest-risk areas should be rezoned for permanent tree cover. High risk areas are those where the following characteristics coincide:

- steep slopes (all areas of >35 degrees, most of 30-35 and some of 25-30 degrees),
- high intensity rainfall (see Fig 1.3 in Annex 4),
- areas of concavity (influx of water)
- absence of deep taproots of perennial trees;
- deep soil (particularly >200cm).

Human interventions such as cuts into the slope for roads or houses, or further cultivation of the slope, can increase landslide risk further.

- ii) New building should be carefully vetted in landslide-risk areas. This includes building on private land as well as public building and roads.
- iii) In the highest risk areas the WMAF in association with the Disaster Preparedness Committee should warn local people during periods of very high risk, i.e. when hurricanes or tropical storms are forecast at times when soils are already at field capacity. Temporary relocation in safe nearby buildings (e.g. schools) could be provided for these people during these relatively short periods. Local committees could also be more involved in undertaking inclinometer-type monitoring of very high risk areas, particularly on a daily or hourly basis during high risk periods.
- iv) Rapid replanting of landslip materials and exposed river banks to cover-crop species should be carried out. Landslips on private land, misused for cultivation, should be planted to permanent treecrops.

b) Flood Risk

- i) Floods in St Lucia are always flashy and are over within 6 hours or so. Coastal towns and villages, invariably built adjacent to river mouths, have an additional hazard of storm tides and surges increasing water levels during many cyclone-induced flood periods. Periods of high flood risk coincide with periods of high landslide risk: Disaster Preparedness Committees and WMAFs must aim to address the issue of both risks occurring concurrently.
- ii). Floodplain hazard mapping has been undertaken for the whole island with flood extent lines marked on the 1:2,500 maps. Severity of flooding, however, will be variable within this area: generally the higher up the watershed, the more aggressive will be the flood wave due to the steeper slope and more confined conveyance channel. Certain watersheds are confined or narrow over much of their length and can cause considerable damage when funnelled flows reach the downstream centres of population (e.g. Canaries, Castries, Dennery). There is urgent need for tighter planning controls within the flood hazard areas: if building is allowed, it should be with an open lower storey.
- iii) Infrastructure affected by the flooding during TSD and 26 October 96 is in danger of being affected by future flooding situations. That infrastructure affected, and those dwellings damaged, should be addressed as part of WMAF activities. Recommendations should be made for flood proofing, flood protection measures or for the relocation of the structure.

c) Land Zoning

Building should be encouraged in the drier, less steep areas, nearer the coast (especially Agro-ecological Zones Em and Dm, - see **Figure 1** of Annex 4), and discouraged in steeper, inland areas. The Land Taxation mechanism coupled with a computerised Land Bank could be used to facilitate the planning process.

4.9.4 Engineering & Operations

- a) No new road construction (or road repair) should be allowed in sensitive areas, ie steep or landslide prone areas, or above drinking water intakes.
- b) Materials from de-silting operations should be selectively moved to nearby shallow soil areas on adjacent upland areas, to increase capability of these lands.
- c) The function of the floodplains as a vital overspill during floodpeaks and as a trap for silt and debris should be appreciated. Riverbanks should be protected by at least a double row of trees. Straightening of river channels should be discouraged. Building on the floodplain, particularly in the lowermost parts, should be discouraged. Land zoning for these areas needs urgently to be re-assessed.

4.9.5 Water Resources Management and Monitoring

- a) Upper watershed areas are not covered by any recent aerial photography, and this is a major constraint in land use studies and monitoring. Conventional air photography is not suitable for these conditions. It is thus recommended that Small Format Air Photography be commissioned, which would involve photography from a helicopter hired at short notice on an hourly basis.
- b) Continuous flow gauges and sediment gauges on major rivers need to be installed. The dry season river discharge monitoring programme needs to be made more systematic and regular. The dry season discharges would be mainly gauged by current metering; these values need to be analysed in the context of upstream abstractions and the rainfall characteristics of the period prior to gauging.
- c) Dry Season water resources are very scarce and there is little scope for major irrigation development and irrigation expansion (if any), should thus be concentrated on the highest value (mainly horticultural) crops. However, the database on dry season flows is small and needs to be improved to enable a forthcoming FAO irrigation study to be well founded. Considering the scarcity of dry season water, there is need to introduce the licensing of abstractions and some means of charging for irrigation water, preferably by volume but at least by irrigated area. Legislation on this needs to be designed and effected.
- d) Improved water quality monitoring is advocated, particularly of the river waters upstream of WASA intakes, and such testing should include pesticide residues. Sampling of lower positions in the river systems, particularly during the Dry Seasons, also needs to be undertaken.

4.2.4 Engineering & Operations

- 1) The best road construction (or road repair) should be allowed in sensitive areas. It may be possible to use concrete or other durable water impervious materials.
- 2) Materials from de-storing operations should be selectively moved to nearby shallow soil areas to avoid runoff and erosion to increase capability of these lands.
- 3) The location of the floodplain as a vital overlap during floods and as a trap for silt and debris should be appreciated. Riverbanks should be protected by at least a double row of trees. Planting of trees should be discouraged. Building on the floodplain, particularly in the floodplain, should be discouraged. Land zoning for these areas needs urgently to be reviewed.

4.2.5 Water Resource Management and Monitoring

- 1) The water resource areas are not covered by any recent aerial photography and this is a major deficiency. Aerial photography and monitoring. Conventional air photography is not suitable for these areas. It is recommended that small format air photography be commissioned, which would provide photography from a helicopter fixed at short notice on an hourly basis.
- 2) Continuous flow gauges or sediment gauges on major rivers need to be installed. The dry season flow gauges monitoring programme needs to be made more systematic and regular. The dry season discharge would be mainly gauged by current measuring. These values need to be adjusted in the context of upstream abstractions and the rainfall characteristics of the period prior to gauging.
- 3) Dry season water resources are very scarce and there is little scope for major irrigation development and irrigation expansion (if any) should thus be concentrated on the highest value (mainly agricultural) crops. However, the database on dry season flows is small and needs to be improved to ensure a preliminary FAO irrigation study to be well founded. Considering the scarcity of dry season water, there is need to introduce the licensing of abstractions and some means of allocation for irrigation water, possibly by volume but at least by irrigated area. Legislation on this needs to be developed and adopted.
- 4) Improved water quality monitoring is required, particularly of the river water upstream of WAGA intake, and such testing should include pesticide residues. Sampling at lower reaches in the river system, particularly during the dry season, also needs to be undertaken.

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Chapter 5

5 AGRICULTURAL ISSUES

5.1 INTRODUCTION

This chapter looks at agricultural, land suitability, problems with current land use and resultant soil loss. Given the non sustainability of the existing system, improvements are proposed both by tackling the erosion problem on existing steep banana land and the possibilities for replacement with permanent fruit tree crops are explored.

After analysing constraints, an attempt is made to calculate the financial implications, for which proposals are also contained in this report.

5.2 LAND SUITABILITY

5.2.1 Ecologically Suitable Crops

With a large variation in agro-ecological zones, practically the full range of tropical crops could be grown successfully somewhere in the island. For the perennial crops, these could include (in decreasing order of rainfall requirement): tea, rubber, oil palm, cocoa, banana, coffee, cinnamon, clove, pepper, coconut, sugarcane, cotton, cashew, plus a wide range of tropical fruits including avocado, breadfruit, carambola, citrus, mango, papaya, passion fruit and pineapple. On flatter land a wide range of seasonal crops could be grown, including taro, yams, sweet potatoes, arrowroot, maize, grain legumes, peppers, and many vegetables.

Because of limitations of slope, clayey soils, and for many alluvial areas increasingly flooding, seasonal crops are less well suited to St. Lucian conditions. Thus the tropical rootcrops, ideally suited to the more sandy and loamy soils in neighbouring St. Vincent, are not so suited to St. Lucia. The requirement thus is for perennial crops giving good ground cover, and high litter production and tolerant weed cover.

Of the perennial crops, tea, rubber and oilpalm, which are ecologically very well suited to the sloping lands of St Lucia would be unsuitable because of requirement for concentrations of suitable land around central processing factories, and a heavy investment requirement for these factories. Labour costs are also a critical factor, and a high labour cost in St Lucia (US\$15 / day, cf \$5 / day for many competing countries) would make tea and rubber uneconomic. Oilpalm would likewise not be suited because of a requirement of at least 6,000ha of land in close proximity to a factory, with the land ideally of under 15 degrees slope.

For the drier lands sugarcane would be fairly well suited, although slope again would have been a major constraint, as well as competing demands for land (construction) and high labour costs.

The Agro-climate of the Island, leading to Agro-ecological Zoning, is reviewed in Chapter 2, with zones being defined on average months which are 'v.wet', 'wet', 'dry' and 'v.dry'. However, year-to-year and season-to-season variation is also extremely important, and such variability was also studied using crop / soil water balance modelling (see Annex 4). An output covering banana cultivation at Union (on the border between Agro-ecological Zones 'C' and 'D') is shown in **Figure 5.1**, with intensity of red coloration being proportional to the intensity of drought (i.e. lower ETa: ETc ratio for the 5-day periods). Note the severity of drought in 1980, 1983 and especially 1987) conversely 1990 and 1995 were relatively good years.

5.2.2 Land Utilisation Types (LUTs) for St Lucia

Potential land uses for St Lucian conditions have thus been reduced to seven main agricultural land utilisation types: bananas, coconut, cocoa, minor treecrops (mainly fruits), cashew, grazing, and annual crops. Construction (residential, tourism, commercial), and two forestry land utilisation types need also to be considered: Natural Forest, and Commercial Forest Plantations.

Figure 5.1

UNION AGR.: BANANA CULTIV.: RATIO OF ETa:ETc FOR EACH PENTADE FOR THE YEARS 1980-95

Pentade	Pnt.No	RATIO OF ACTUAL TO POTENTIAL EVAPOTRANSPIRATION FOR EACH PENTADE														
		80	81	82	93	84	85	86	87	88	89	90	91	92	93	94
05-Jan	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10-Jan	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
15-Jan	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
20-Jan	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
25-Jan	5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
30-Jan	6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
04-Feb	7	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
09-Feb	8	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
14-Feb	9	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8
19-Feb	10	0.9	1.0	1.0	1.0	1.0	1.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8
24-Feb	11	0.9	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.6
01-Mar	12	0.9	1.0	1.0	0.8	1.0	1.0	0.4	1.0	1.0	1.0	1.0	0.9	0.9	1.0	0.6
06-Mar	13	0.8	1.0	1.0	0.7	0.9	1.0	0.9	0.4	1.0	1.0	1.0	0.9	1.0	1.0	0.5
11-Mar	14	0.8	1.0	1.0	0.7	0.9	0.9	0.8	0.3	0.9	1.0	1.0	0.7	1.0	1.0	0.4
16-Mar	15	0.7	1.0	1.0	0.5	0.8	0.7	0.7	0.2	0.8	0.8	1.0	0.8	0.7	1.0	0.9
21-Mar	16	0.6	1.0	1.0	0.5	0.8	0.7	0.6	0.2	0.6	1.0	1.0	0.6	0.6	1.0	0.7
26-Mar	17	0.6	1.0	0.9	0.4	0.7	0.6	0.6	0.1	0.5	1.0	0.9	0.7	0.5	1.0	0.6
31-Mar	18	0.5	0.8	0.7	0.4	0.8	0.7	0.9	0.3	0.4	1.0	0.9	1.0	0.5	1.0	0.7
05-Apr	19	0.3	0.8	0.5	0.3	0.6	0.7	0.9	0.2	0.8	1.0	0.7	0.9	0.4	0.8	0.7
10-Apr	20	0.3	0.6	0.4	0.3	0.6	0.5	0.7	0.2	0.7	1.0	0.9	0.9	0.4	0.7	0.5
15-Apr	21	0.2	0.6	0.5	0.2	0.5	0.5	0.5	0.2	0.5	1.0	0.8	0.9	0.5	0.5	0.4
20-Apr	22	0.4	1.0	0.7	0.2	0.4	0.5	0.4	0.2	0.4	1.0	0.7	0.7	0.6	0.4	0.6
25-Apr	23	0.3	1.0	0.6	0.3	0.5	0.4	0.4	0.2	0.3	1.0	1.0	0.6	0.7	0.4	0.5
30-Apr	24	0.4	1.0	0.5	0.2	0.5	0.8	0.6	0.2	0.2	1.0	0.9	0.5	0.5	0.8	0.4
05-May	25	0.4	1.0	0.4	0.3	0.5	0.6	0.5	0.2	0.4	1.0	0.7	0.4	0.6	0.8	0.8
10-May	26	0.3	1.0	1.0	0.3	0.7	0.5	1.0	0.2	0.4	1.0	0.7	0.3	0.6	0.9	0.6
15-May	27	0.2	1.0	0.8	0.7	0.5	0.8	1.0	0.4	0.3	1.0	0.7	0.2	0.9	0.7	0.5
20-May	28	0.3	1.0	0.7	0.6	0.5	0.6	1.0	0.8	0.3	0.8	1.0	0.8	0.8	0.6	0.4
25-May	29	0.4	1.0	0.6	1.0	0.4	0.7	0.9	1.0	0.3	0.7	0.8	0.5	0.7	0.5	0.3
30-May	30	0.7	1.0	0.7	1.0	0.3	0.5	0.8	1.0	0.4	0.6	0.8	0.7	0.6	0.8	0.4
04-Jun	31	0.6	1.0	0.6	1.0	0.5	0.4	0.7	1.0	0.4	0.5	0.9	0.5	1.0	0.6	0.7
09-Jun	32	0.8	1.0	0.6	1.0	0.4	0.3	0.9	1.0	0.4	0.4	0.8	0.5	1.0	0.5	0.9
14-Jun	33	0.7	1.0	0.6	1.0	0.5	0.3	0.9	1.0	0.6	0.4	1.0	0.7	1.0	0.5	0.7
19-Jun	34	0.9	1.0	0.7	1.0	0.4	0.2	0.8	1.0	0.6	0.6	1.0	0.5	1.0	1.0	0.8
24-Jun	35	1.0	1.0	0.7	1.0	0.3	0.3	0.7	1.0	1.0	0.4	1.0	0.4	1.0	1.0	0.6
29-Jun	36	1.0	1.0	0.5	1.0	0.7	0.3	0.9	1.0	0.9	0.5	1.0	0.9	1.0	1.0	0.5
04-Jul	37	1.0	1.0	0.4	1.0	1.0	0.7	0.7	1.0	1.0	0.5	0.9	1.0	1.0	0.9	0.8
09-Jul	38	0.9	1.0	0.7	1.0	1.0	0.5	0.6	1.0	0.9	1.0	1.0	1.0	1.0	0.9	0.6
14-Jul	39	0.9	1.0	0.6	1.0	1.0	0.7	0.7	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.5
19-Jul	40	1.0	1.0	0.6	1.0	1.0	0.9	0.8	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.5
24-Jul	41	1.0	1.0	0.7	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7
29-Jul	42	1.0	1.0	0.8	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0	0.9	1.0	1.0	0.7
03-Aug	43	1.0	1.0	0.9	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0	0.8	1.0	1.0	0.7
08-Aug	44	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0
13-Aug	45	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0
18-Aug	46	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0
23-Aug	47	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0
28-Aug	48	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
02-Sep	49	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
07-Sep	50	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
12-Sep	51	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
17-Sep	52	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
22-Sep	53	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
27-Sep	54	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
02-Oct	55	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
07-Oct	56	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
12-Oct	57	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
17-Oct	58	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
22-Oct	59	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
27-Oct	60	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
01-Nov	61	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
08-Nov	62	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
11-Nov	63	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
16-Nov	64	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21-Nov	65	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
26-Nov	66	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
01-Dec	67	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
06-Dec	68	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
11-Dec	69	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
16-Dec	70	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21-Dec	71	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
26-Dec	72	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
31-Dec	73	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Land requirements for these LUTs can be summarised as follows:

- a) **Bananas:** even rainfall distribution, with an average of no more than one 'very dry' month (200mm accumulated rainfall deficit) per year. Not exposed to high wind; cloud cover and humidity not too intense; elevation < 1200 feet; soils deep, well drained, low resistance to root penetration, high AWC and CEC, high fertility status (may be applied artificially); slopes ideally not more than 25 degrees; close proximity to roads;
- b) **Coconuts:** as above, but a greater tolerance to dry periods (3 very dry months and 400mm accumulated rainfall deficit); preference for deep, lighter textured soils; slopes up to 35degrees.
- c) **Cocoa:** as for bananas, but requirement for not excessive rainfall and humidity in wet season (<5 very wet months/year); soils of higher pH (5.7-6.5), high natural fertility status and high AWC and CEC; slopes not above 30 degrees.
- d) **Minor treecrops (fruits):** as for bananas, but some show greater tolerance to wetter conditions and a much wider range of soil types; slopes up to 35 degrees; proximity to farmer's house (to reduce praedial larceny);
- e) **Cashew:** requirement for appreciable dry season 2-5 'very dry' months; very tolerant of poor soil conditions, particularly in moister areas; slopes up to 30 degrees;
- f) **Grazing:** as for bananas, but more tolerant of poorer soil conditions, although less clay and higher infiltration rate is important; slopes up to 25 degrees;
- g) **Annual crops:** as for bananas, but strict requirement for land of gentle slopes (<10 degrees);
- h) **Commercial Forest Plantations:** wide range of species enable plantations to be established over a wide range of agro-ecological zones; reasonably tolerant of poor soil types; slopes up to 40 degrees;
- i) **Construction:** not suited to flood hazard areas, or areas with appreciable landslide hazards (thus most of Zones A and B).

5.2.3 Suitability Ratings for the 10 LUTs

Suitability ratings for the 10 LUTs have been assigned to the best 35% of the land represented by each of the 20 agro-ecological zones. These ratings are shown in **Table 5.1**.

5.3 SOIL EROSION AND CONSERVATION

5.3.1 Extent of Cultivated Land in Problem Slope Classes

Areas of land in each of the Agro-ecological zones, broken down by watershed, are shown in **Table 2.5** (chapter 2). Percentages of land within different slope classes have been estimated for each of these zones, and these are presented in **Figure 2.3** (legend accompanying map). This slope estimation has been based on a compilation of four sources: original soil and land capability survey by Stark et al (19966); automatic slope mapping and analysis from the 1:25,000 topo map (Min. of Planning GIS Unit, 1997); detailed sample area analyses in Cul de Sac and comparison with the former two sources; and the Consultants' field observations in different areas during 1996-97.

In Annex 4 existing land use mapping for the island was reviewed. The most up-to-date comprehensive coverage was by Roche Itee (1993), but this was based on satellite imagery (effectively at 1:50,000 scale) which is insufficiently precise for separation of cultivated areas, let alone breakdown of cultivated areas into specific crops. The Consultants' Small Format Air Photography (1:5,000 and 1:7,500 scales) has been able to give much more precise land use mapping, but, due to bad weather and delays in undertaking the SFAP, time has been insufficient to complete this for more than about 2000 acres.

Failing a detailed island-wide land use survey, giving a breakdown of banana land in different watersheds, agro-ecological zones, and slope classes, the Consultants again have made a preliminary estimate, and this is shown in **Table 5.2**. Indicative areas of banana land within the slope classes 0-20, 20-30 and >30 degrees are shown for each watershed. Approximate average annual soil losses from this land has also been estimated, and this is given for each watershed in the last column of **Table 5.2**. A total soil loss of 300,000 tonnes per year, due to bananas alone, is estimated: i.e. for every tonne of bananas produced some 2-3 tonnes of soil is eroded. Almost half of this erosion would be due to cultivation on slopes of more than 25 degrees, although this land represents only slightly more than 20% of the total banana acreage (and probably much less than 20% of St Lucia's banana production as yields are lower on the steeper holdings).

Contributions from other misuses of land have also been estimated, based on detailed SFAP assessments of the pilot watersheds (see Chapter 6) and assumptions on erosion rates per unit area. Cultivation of annual crops, and construction land uses (residential, industrial/institutional and road infrastructure) may contribute very much more than bananas to erosion, but these misuses usually occur over much smaller areas, particularly on the steeper slopes. For the Cul de Sac (Ravine Poisson) sample area, total erosion due to these misuses was only 25-30% of that due to bananas. However, this situation could quickly change: there are indications that abandoned banana land is going into seasonal crops, and the gross misuses of land associated with road projects (see **Figure 4.4** Chapter 4) locally may cause massive erosion and siltation.

5.3.2 Soil Conservation Practices

Given the fact that bananas are responsible for some 65-70% of eroded soil material in the country, soil conservation practices suitable for banana cultivators is of top priority. This has received some attention from WINBAN, and reported on by David Harris. Generally mechanical methods of conservation (bench terraces, contour ridging) are not appropriate, partly because of cost, and partly because they may add to the tendency for mass movements on steeply-sloping land. Any large amount of water retained on the contour in steep, concave areas would increase the risk of landslides.

Of the biological (agronomic) measures, cover crops are not generally appropriate, because of intense shading by well-established banana canopies, a situation which should prevail after month 7 in the plant crop, and continuously for subsequent ratoon crops. Similarly the use of vetiver (*Khus-Khus*) grass is not appropriate within the banana fields, as was investigated by Harris, although possible use at the edge of fields, or by the side of deep, widely-spaced drains, should not be ruled out. Use of inputs at the recommended level will establish a dense canopy in minimal time, and will thus confer additional benefits in soil conservation.

The most appropriate soil conservation measure in banana fields is clearly much better trash management, comprising both maintenance of a uniform trash cover, and installation of trash lines on the contour (see **Figure 4.3** Chapter 4). In the Consultants' field trials, good trash cover was shown to increase infiltration rates by 100%, in addition to protecting the mineral soil surface and binding mineral and organic materials in a network of surface roots (see Section 4.8).

TABLE 5.1 : ST LUCIA: AGRO – ECOLOGICAL ZONING MAP: LAND SUITABILITY RATINGS FOR MAJOR LAND UTILISATION TYPES

UNIT	SUITABILITY RATINGS FOR BEST 35% OF UNIT FOR MAJOR LAND UTILIZATION TYPES										OPTIMUM LAND USE
	Banana	Coconut	Cocoa	Minor Tree-crops	Cashew	Natural Vegetation (Forest)	Comm-ercial Forestry	Grazing	Annual Crops	Cons-truction	
Ah	N2cst	N2cst	N2cst	S3cst	N2cst	S1	S3ct	N2ct	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Ar	N2cst	N2cst	N2cst	N2cst	N2cst	S3st	N2cst	N2ct	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Bh	S3cst	S3cst	S3cst	S2ct	N2cst	S1	S2ct	S3ct	N2cst	N2st	Minor Treecrops: bananas on slopes < 25deg
Bk	S3cst	S3cst	S3cst	S2ct	N2cst	S1	S2ct	S3ct	N2cst	N2st	Minor Treecrops: bananas on slopes < 25deg
Br	N2cst	N2cst	N2cst	N2cst	N2cst	S3st	N2cst	N2cst	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Ba	S2cf	S3cst	S3cdf	S2cf	N2cst	S1	S2ct	S2cf	S2f	N2sf	Bananas; some annual crops.
Ch	S2t	S2t	S2t	S2ct	S3ct	S1	S1	S2cst	S3cst	S3st	Bananas on slopes < 25deg; minor treecrops on slopes over 25 deg.
Ck	S2st	S2st	S2st	S2ct	S3ct	S1	S1	S2cst	S3cst	S3st	Bananas on slopes < 25deg; minor treecrops on slopes over 25 deg.
Cm	S2st	S2st	S2st	S2ct	S3ct	S1	S1	S2cst	S3cst	S3st	Bananas on deeper soils, < 25deg; minor treecrops on slopes > 25deg.
Cr	N2cst	N2cst	N2cst	N2cst	N2cst	S3st	N2cst	N2cst	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Ca	S2f	S2cst	S2cdf	S2cf	S3ct	S1	S1	S2cf	S2cf	N2sf	Bananas; some annual crops.
Dk	S2ct	S2ct	S2ct	S2ct	S2c	S1	S1	S1	S3cst	S2st	Bananas on slopes < 25deg; minor treecrops on slopes over 25 deg.
Dm	S3cst	S3cst	S3cst	S3cst	S2c	S1	S2c	S2cs	S3cst	S2st	Bananas on slopes < 25deg; minor treecrops on slopes over 25 deg.
Dr	N2cst	N2cst	N2cst	N2cst	N2cst	S3st	N2cst	N2cst	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Da	S2cf	S3cdf	S3cdf	S2cf	S2c	S1	S1	S2cf	S2cf	N2sf	Bananas; some annual crops.
Em	N2cs	S3cst	N2cs	N2cs	S2c	S1	S2c	S2cs	S3st	S1	Cashew; Landscaped construction
Ek	S3cs	S2cst	S3cs	S3cs	S2c	S1	S2c	S3cs	S3st	S1	Cashew; Landscaped construction
Er	N2cst	N2cst	N2cst	N2cst	N2cst	S3st	N2cst	N2cst	N2cst	N2st	Natural vegetation (forest) only: watershed protection – wildlife habitat.
Ea	S3cf	S3sf	N2cdf	S3csf	S2c	S1	S2c	S2cf	S3cf	N2sf	Bananas; some annual crops (irrigated).
Fm	N2cs	N2cs	N2cs	N2cs	S3c	S1	S3cs	S3cs	S3st	S1	Landscaped construction
Fa	N2cf	S3csf	N2cf	S3csf	S2c	S1	S2c	S3cf	S3cf	N2sf	Some annual crops (irrigated).

S1, S2, S3, N2: Highly, moderately, marginally suitable, permanently not suitable respectively.
 Note: Mapping Units are the Agro – Ecological Zones of Fig 2.3 – see map and full legend.

Subclass limitations: c.s.t.f: climate, soil, topography, flooding.

TABLE 5.2 : ST LUCIA: BANANA LAND IN EACH WATERSHED & RESULTING AMOUNTS OF EROSION PER YEAR

Nr Watershed Name	Area (km ²)	Rainfall		Banana Land (Ha)			Amount of erosion ('000tonnes/yr) at respective rates of (tonnes/ha/yr):			
		Volume b	Depth cu m (mm)	0-20	20-30	>30	20	60	100	Total
1 Salle/Lapins	6.7	10.3	1530	17	1	0	0.3	0.1	0.0	0.4
2 Esperance	9.7	16.5	1700	27	9	2	0.5	0.5	0.2	1.2
3 Trou Grauvai / Dauphin	10.0	16.3	1630	28	11	2	0.6	0.7	0.2	1.5
4 Marquis	31.0	67.3	2170	302	145	49	6.0	8.7	4.9	19.7
5 Grande Anse / Louvet	29.2	52.9	1810	141	80	21	2.8	4.8	2.1	9.7
6 Fond d'Or	41.0	98.4	2400	527	172	64	10.5	10.3	6.4	27.3
7 Dennery <<<<	21.4	44.7	2090	216	91	30	4.3	5.5	3.0	12.8
8 Riviere Galet / Trois Islet	11.0	19.4	1760	56	28	7	1.1	1.7	0.7	3.5
9 Marniku / Pattence	16.0	29.4	1840	100	54	17	2.0	3.2	1.7	6.9
10 Fond	18.1	45.1	2490	145	71	26	2.9	4.3	2.6	9.8
11 Volet	8.6	16.9	1970	34	28	9	0.7	1.7	0.9	3.3
12 Troumassee	31.7	91.0	2870	194	80	32	3.9	4.8	3.2	11.9
13 Micoud / Ravine Bethel	13.1	24.9	1900	62	29	8	1.2	1.7	0.8	3.7
14 Canelles	17.3	43.1	2490	146	60	21	2.9	3.6	2.1	8.6
15 Roarne/Rugeigne/Palmiste/St Urban	22.8	36.5	1600	94	24	2	1.9	1.5	0.2	3.6
16 Vieux Fort	28.8	63.9	2220	174	76	25	3.5	4.5	2.5	10.5
17 Black Bay	15.2	26.9	1770	99	42	13	2.0	2.5	1.3	5.8
18 Laborie	5.5	8.9	1620	24	3	0	0.5	0.2	0.0	0.7
19 Piaye	9.6	22.3	2320	71	44	16	1.4	2.6	1.6	5.6
20 Balembouche	5.2	10.1	1950	27	12	4	0.5	0.7	0.4	1.6
21 Doree	11.1	29.4	2650	50	33	13	1.0	2.0	1.3	4.3
22 Choiseaul / Trou Barbet / Trou Marc	18.1	36.2	2000	88	63	30	1.8	3.8	3.0	8.6
23 L'ivrogne	6.5	14.7	2260	80	24	10	1.6	1.5	1.0	4.0
24 Pitons	7.1	13.5	1910	22	23	8	0.4	1.4	0.8	2.6
25 Soufriere	17.2	42.1	2450	170	97	46	3.4	5.8	4.6	13.9
26 Mamin / Mahaut	13.7	26.2	1910	87	47	12	1.7	2.8	1.2	5.8
27 Canaries	14.6	37.2	2550	74	48	21	1.5	2.9	2.1	6.5
28 Anses la Verdure / Cochon / Galet	13.1	27.6	2110	61	43	14	1.2	2.6	1.4	5.2
29 Grande Riviere de Anse-la-Raye	8.9	23.8	2670	84	42	19	1.7	2.5	1.9	6.0
30 Petite Riviere de Anse-la-Raye	5.7	12.6	2210	45	26	11	0.9	1.6	1.1	3.6
31 Roseau	49.1	145.3	2960	708	154	82	14.2	9.3	8.2	31.7
32 Mt. Bellevue	4.8	9.0	1870	16	6	1	0.3	0.3	0.1	0.8
33 Cul de Sac <<<<	40.9	112.9	2760	838	189	103	16.8	11.4	10.3	38.4
34 Castries	14.3	29.6	2070	65	47	13	1.3	2.8	1.3	5.4
35 Choc	12.7	28.6	2250	102	61	20	2.0	3.7	2.0	7.7
36 Bois d'Orange	11.3	21.0	1860	110	20	6	2.2	1.2	0.6	4.0
37 Cap	15.4	23.7	1540	52	3	1	1.0	0.2	0.1	1.3
TOTALS (Areas in sq km)	616.4	1378.2	2240.0	5137	1989	758	103	119	76	298

Note: Preliminary estimate only, based on extrapolations from sample areas.

However, given the extent of the problem, very little has been done to control soil erosion on banana land. The WINBAN Banana Handbook, several agronomic papers by David Harris, and the current Code of Practice for Banana Growers all emphasise the importance of trash management but this has not been promoted at field level. Lack of action here is due to five main causes:

- WINBAN / SLBGA giving first priority to promoting banana quality, and high priority to other items on the certification programme which are relatively easy to check and which give an immediate financial return;
- promotion of inputs and practices which give quick returns and have been thoroughly tested in field experiments – e.g. balanced chemical inputs. Although results in terms of effectiveness of ground cover and contribution to increasing infiltration and reducing run-off and erosion are not in doubt, there is still need to proceed with further testing of banana trash practices at the field level to investigate indirect implications of the trash – e.g. snail and possible nematode problems;
- insufficient funds for SLBGA extension activities: soil conservation, being a long-term activity, always appears at the bottom of the list;
- a split in responsibility for soil conservation extension between the MAFF&E and the SLBGA;
- relative unpopularity in undertaking soil conservation extension vis a vis other extension activities. Field work on steeply sloping land, a long way from the nearest road, and under rainy conditions was clearly not popular during the Land Use and Agricultural Consultant's 1996-97 inputs (see Annex 7 on the Field Trials).

5.3.3 Recommended Action on Soil Conservation

For Soil Conservation in Banana Land, the Consultants would advocate promotion of trash management through WIBDECO / SLBGA's Certified Growers Scheme. To do this it is recommended that five SLBGA Officers be appointed as soil conservation officers, with the sole responsibility of ensuring that certified farmers comply with criteria for optimal trash management. As this is a long-term activity, and as SLBGA is under severe financial pressure, it is advocated that these officers be financed completely through a grant from the LCB, although they would continue to be responsible to the SLBGA. Each officer would be responsible for a different SLBGA Division, and, through SLBGA, targets for certification and general soil conservation extension activities would be monitored. It is advocated that 4x4 vehicles be provided and some funds and facilities be made available through the WMAFs to undertake related activities such as establishment of glyricidia plantings for stakes for the trash lines, planning layouts of surface drainage, and particularly tied contour drains in farmer's fields.

The SLBGA and the Growers Scheme would also be involved in the programme to promote perennial tree plantings within steep existing banana fields. Even though the banana acreage would be reduced by this measure, the BGA would benefit in that the most marginal banana land with respect to both yields and quality would be taken out of banana production. Also flood-related problems in the good banana lands in the floodplains would be alleviated by this measure.

For this 5-year period it would be advocated that funds be obtained through a grant or loan to the Government. As a longer term measure, it would be hoped that these officers would be sponsored by the tourist hotels in or near their respective watershed areas, as the main beneficiaries of cutting the annual loss of some 300,000 tons of soil would be the tourist industry itself.

Soil Conservation activities in other land would be the responsibility of the MAFF&E extension officers, most of these acting through the WMAFs. These extension officers need to focus on alternative crops, both tree crops on the steeper land, and annual crops on the gently-sloping land. Also roadside vetiver and cover crop planting, and plantings in the river reserves need to be tackled as high priority items.

5.4 CROP DIVERSIFICATION

5.4.1 General

The 1960s saw the demise of the sugar industry and the first commercial banana plantings in St. Lucia. From a modest 5,500 acres, planting had increased to 13,200 acres by 1986 and to an estimated 19,000 acres by 1996. Much of this increase in acreage, driven by high prices in the mid 1980s, was on steep hillsides and in many cases existing tree crops were felled to make way for bananas. In response to demands from farmers, feeder roads were constructed giving access to these new lands with little thought to conservation or environmental issues.

By the late 1970s, some more astute observers began to feel uneasy with the increasing dependence on a single crop, and 1979 saw the first serious attempt to promote diversification, but again, concern over the deterioration of the environment was not the major concern. The need for diversification, particularly into tree crops, has become progressively more evident over the years, but the various initiatives met with little success in terms of farmer acceptance.

It took the impact of TSD to bring home the urgent need for better conservation of the steep upper catchment areas and concurrent with this, falling banana prices and low profitability have put the marginal hillside farmers under pressure.

The term "diversification" covers a multitude of crops, both annual and perennial and including flowers, but here we refer only to tree crops, having a potential to conserve the steep slopes, while at the same time providing an income for the farmer.

Misuse of the steep land in the upper catchments where forest cover had been removed and land planted to bananas has been diagnosed as a major cause of erosion in the uplands and flash flooding and siltation of river systems/drains in the valley bottoms. The solution is seen as a progressive change into permanent tree crops with potential for conservation and income generation. With current disturbance and restructuring of the banana industry, a positive initiative is essential to obviate the risk of farmers either abandoning land, or planting annual crops. Whilst this area of study falls largely outside the Consultant's ToR, and is peripheral to LCB's mandate, sufficient work has been done to indicate an outline programme.

The Watershed and Environment Management Project has looked at erosion prevention from two perspectives:

- erosion control measures on all banana land;
- a progressive change in land use on the steepest land.

The need for urgent action was spelt out in the Socio Economic Background (Annex 10 and section 2.4 of this report) and further technical studies formed the basis of Annex 5, 'Possibilities for Alternative Cropping', on which this section is based.

5.4.2 A Brief Historical Perspective

In looking for a way forward it is necessary to review past initiatives, their successes and failures, and to structure any new proposals in such a way as to avoid past mistakes and tackle the problem from a different angle.

From both the need to diversify the economy and reduce vulnerability and later for conservation reasons, diversification has long been a topic for serious discussion and intermittent activity. The first significant attempt at increasing the planting of tree crops, was the Orchard Crop Diversification Project (OCDP) funded by BDDC, and which ran from 1979 to 1985. Some additional acreage,

estimated at 440 acres of fruit tree crops were established, although mostly not in orchards or plantations as had been envisaged.

The Heads of OECS Governments met in St. Lucia in March 1988 specifically to discuss diversification and resulting from these deliberations, the Agricultural Diversification Coordinating Unit (ADCU) was established in December 1989, with its headquarters in Dominica. ADCU's brief was:

- to examine and develop market potential
- to develop a database of UK market prices
- to circulate information on market prospects to OECS member states
- to protect private exporters from exploitation by dubious operators and importers.

In 1990, major funding became available with the advent of West Indies Tropical Produce Support Project (TRoPRo). The project, funded by USAID to the value of US\$ 10 million, ran from 1990 to 1996. Implementation was coordinated by ADCU with a heavy involvement of the Caribbean Agricultural Research Institute (CARDI).

The project concentrated on four main areas:

- production – to increase the quantity and improve the quality of exportable produce;
- post harvest handling – to improve the sorting, grading, handling, packing and storage of produce both to bring its presentation to international standards and to decrease losses;
- transport – to provide a more efficient system of intra-regional transport for the export of produce;
- market information system – to increase the market knowledge and market contacts of the region's produce exporters.

The highest impact at a general level was achieved in the quality assurance programme and marketing information service, while individual exporters benefited from supplies of packhouse equipment and packaging materials, training, market visits, routine contact with TRoPRo staff, inspection reports and provision of market intelligence information.

Less successful was the establishment of linkages between marketing and production, where marketing moved ahead faster than production. The initial focus on too broad a range of crops resulted in less detailed attention than was desirable, although this was subsequently rectified. Efforts to channel post harvest and marketing information systems, also suffered deficiencies.

5.4.3 The Current Situation

The current situation reflects many of the weaknesses diagnosed almost twenty years ago, namely:

- Agronomy and management;
- The lack of supporting institutions at farm level;
- Transport;
- Low production and variable fruit quality.

Generally, farmers do not regard fruit trees as a cash crop, but see them as a source of additional seasonal income. Little attention is paid to pests, diseases, fertiliser or other inputs. Much of the technology exists but a change in attitude is essential before progress can be made.

During TroPRo, a lack of liaison between the project and Ministries of Agriculture was diagnosed as a weakness and led to a non coordination of the drive for more and better fruit into country

agricultural programmes. This largely persists to this day. Trial shipments, negotiations on freight rates and improvements in packaging, have had benefits, but the pilot work has not been fully exploited. Exporters in St. Lucia continue to compete for freight space on the many tourist aircraft and no use is being made of the Geest Line banana boats, which would bring huge benefits in transportation cost of non perishable produce. There is potential for reducing costs from around EC\$ 2 per kilo by air to 45 cents by sea.

Low production continues to be a major problem, although quality has improved, mainly due to private exporter initiative. Apart from attitude and no inputs, inter exporter rivalry and a weak Association of Exporters lead to zero publicity and often farmers with produce fail to find a market while exporters fail to fill their export orders. A serious deterrent to new planting, is the myth of there being no market. If there were continued large production, marketing would become progressively easier. The other major deterrent is the lack of input costs and output value data. The available figures show wide discrepancies and further work is essential if diversification is to take off. Estimated production, over the last five years is given in Table 5.3.

TABLE 5.3 ESTIMATED CROP (TONNES) PRODUCTION 1992-1996

PRODUCE	1992	1993	1994	1995	1996
Banana	143,139.7	140,057.2	96,591.5	119,117.6	112,132.8
Coconut	n.a.	n.a.	n.a.	n.a.	n.a.
Copra	4,098.0	5,039.5	3,583.8	2,622.5	2,389.9
Cocoa	67.8	50.0	64.4	47.1	33.2
Sweet Potato	259.0	333.4	281.6	506.8	557.8
Yams	294.9	347.1	454.0	442.0	595.6
Tannia	35.4	75.7	48.7	42.7	102.4
Tomato	153.4	116.5	182.8	147.7	152.6
Cabbage	124.8	199.8	238.3	231.7	255.5
Cucumber	209.6	208.6	245.0	223.7	260.5
Carrot	44.8	17.5	24.4	8.8	23.8
Sweet Pepper	32.7	35.6	53.0	44.8	65.0
Okra	23.4	45.2	52.4	72.0	65.8
Melon	117.7	79.8	153.2	100.8	102.9
Pumpkin	167.6	135.4	167.5	165.5	172.9
Ginger	3.6	7.2	5.5	6.0	19.8
Lime	134.6	125.5	174.0	172.8	184.6
Sweet Orange	619.0	574.2	698.0	660.4	673.8
Grapefruit	931.1	814.0	898.8	1182.4	887.6
Avocado	205.6	238.1	234.6	250.3	488.9
Dasheen	294.2	395.8	371.3	417.0	647.4
Plantain	777.4	704.0	411.6	531.0	1172.2
Lettuce	79.4	80.4	104.0	90.0	86.0
Breadfruit	2644.0	2318.4	2045.3	1968.8	1999.47
Sour Sop	183.7	251.8	164.7	158.0	109.8
Hot Pepper	173.3	97.7	224.8	304.6	224.5
Mango	2541.6	2197.1	3245.2	1846.0	1959.4
Pineapple	275.7	389.9	347.0	250.9	121.4

Source: Planning and Statistical Unit, Ministry of Agriculture

Incentives in the form of cash grants, free inputs and heavily subsidised seedlings were features of the OCDP Project, which shows that cash alone is not a sufficient incentive to ensure increased planting and production.

5.4.4 Potential for Diversification

Potential may be viewed from two points of view:

- potential area available;
- crops that are suitable and for which good market prospects exist.

While precise figures can only be determined later, and after SFAP and analysis and mapping of land use, current available data can be used to show the appropriate size of the problem areas. Figures are presented in **Table 5.2**.

This shows that there are some 1900 acres of banana land in the over 30° slope class on which a change to permanent tree crops is urgent, and a further 2500 acres over 25 degrees on which change is highly desirable, a total target acreage of 4400. Were this land to be put into fruit tree crops during the next ten years, this would vastly improve conservation and run-off, and provide a useful income to farmers who are almost certainly losing money by growing bananas. The impasse over marketing would also be resolved.

With regard to suitable crops, the Consultants' investigations lead them to believe that sufficient data exists to recommend various crops, and further that these crops represent a viable commercial proposition. Crops in this category are:

- | | |
|------------|------------|
| Avocado | Breadfruit |
| Cocoa | Coconut |
| Grapefruit | Mango |
| Orange | |

An exercise was also carried out using the best data available, to calculate the income lost during a switch from banana to fruit. For convenience Julie Mango was used. This showed a declining income to the fifth year, and increasing profit thereafter. The need for cash incentives was viewed in the light of this and data from this analysis are presented in **Table 5.4**. Yields are expected to increase up to year 20, and expected Financial Internal Rate of Return would be in the order of 15%. The analysis is based on fairly conservative estimates of management and farm inputs, and a subsequent visit by the Consultants to River Dorree Plantation has indicated that over double these yields are achievable under expert management (i.e. 50 fruits per tree in year 5, with 300 trees per acre and EC 35¢ per fruit).

**TABLE 5.4 : INCOME DEFICIT DURING CHANGE FROM BANANA TO MANGO
(50 TREES / ACRE – LOW TECH) FOR A TYPICAL 3–ACRE HILLSIDE FARM (EC\$ / YEAR)**

	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr10	Yr15
Assumed banana revenue	6885	5508	4131	2754	1377	0	0	0	0	0	0
Mango non-harvest costs	0	1122	354	423	708	459	459	459	459	459	459
Mango harvest costs	0	0	0	57	906	1809	2172	2451	2730	3102	4344
Mango revenue	0	0	0	1938	3879	7758	8937	10053	11169	13341	18306
Net Income	6885	4386	3777	4212	3642	5490	6306	7143	7980	9780	13503
Deficit (-) / Additional Income (+)	0	-2499	-3108	-2673	-3243	-1395	-579	258	1095	2895	6618
Internal Rate of Return:	15.3 %										

Note: assumes farmer provides his own labour except for harvesting
Total deficit to Yr 6 is EC\$13497. Finances for project considered over a 20-year period.

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In order to achieve an income flow throughout the year, and to spread risks from loss of income due to sudden falls in prices or losses of yield due to pests and diseases, the Consultants would advocate mixed plantings with a range of up to 7 tree crops. None of these would comprise more than 30-40% of total plantings, with the order and months of bearing throughout the year being:

- Cocoa – February – April
- Breadfruit – April – October
- Mango – May – August
- Avocado – July – October
- Grapefruit – August – November
- Orange – October – February

Trees would be planted on the contour, at a relatively high planting density. Trees would be planted closer together on the contour, and further apart between contour lines. Trash lines would be maintained on the contour, midway between the rows of trees, particularly on the steeper slopes (<math><25^{\circ}</math>). Material for the trash lines would initially come from the banana plants, but later would progressively be replaced by prunings from the tree crops themselves.

5.4.5 The Proposed Programme

In view of the short time the Consultants were able to spend on alternative crops, difficulties encountered in locating and obtaining essential reports, and the importance which they attach to getting a programme of diversification started, a short consultancy is proposed. In consultation with ADCU, CARDI, and MAFF&E staff the consultant would:

- collect and collate all existing data on alternative crops and summarise the situation;
- identify weakness, constraints and deficiencies and propose solutions to rectify;
- recommend a programme of work that would lead to definition of technical packages;
- make recommendations for tree crops by agro-ecological zone;
- prepare input/output gross margins;
- design and cost a programme of on-farm demonstration;
- review institutional involvement and recommend changes where necessary;
- assess the need for incentives, how they would operate and which institution would be most appropriate.

Without wishing to prejudge the outcome of the proposed study, current thinking suggests that the programme is likely to include:

- the inclusion of a Diversification Unit within the overall institutional framework of the LCB;
- the establishment of a one acre on farm demonstration using a mix of fruit tree crops, one for each WMAF and contracted through the WMAF;
- the establishment of targets for conversion, bananas to fruit trees for each WMAF. Initial targets could be 10% of land over 25° slope;
- the deposition of funds to the National Federation of Credit Unions for on lending to farmers at 6% interest, to alleviate loss of income during a change of cropping.

5.5 CONSTRAINTS TO ECONOMIC TRANSFORMATION

Legislation and enforcement as a tool to induce changes in land use is not an option, except in the case of forest reserves and Crown Land. However, enforcement could be extended to cover areas of high risk (landslide hazard) feeder road construction and the building of new houses. In the remaining steep land areas any attempt to force change in land use by legislation is socially unacceptable and practically unworkable, and current high unemployment in rural areas must also be borne in mind. It is clear that alternative employment opportunities does not offer any relief to hillside farmers.

Diversification offers one solution, and could be of benefit to the economy at large in spreading risk and to hillside farmers likely to be squeezed out of banana production. Some key constraints to diversification are explored in Section 3.5.3 including.

- Marketing – farmers have no confidence in the marketing arrangements for alternative crops.
- Technical Skills – farmers only have experience of growing bananas.
- Pre-adial Larceny – crops other than bananas tend to be stolen
- Belief in Banana – farmers cannot believe that the crop will not return to its earlier profitable level.
- Land Tenure – Some 30% of all bananas, are grown on family land where the comparatively short rotation banana is acceptable whereas more permanent tree crops might not be acceptable.
- Farmer Age – the average age for male farmers estimated at 47 years, and lower for females, but perhaps of greater significance, is the reluctance of the younger generations to enter farming.
- Credit – Most farmers have experience of credit and are willing to borrow, so long as they are confident that their investment will yield benefits. Investment in tree crops with 3-4 years costs accumulating before any returns start to flow in could be problematical..

Chapter 6

6 WATERSHED AND ENVIRONMENTAL MANAGEMENT PLANS FOR PILOT WATERSHEDS

6.1 INTRODUCTION

Over the years there has been a progressive deterioration of the environment of the Island. Symptoms of this are the increase in flash floods, heavy siltation of lower valley areas and the initial environment, and very low dry season base flows in the river system. The pace of deterioration has been increasing exponentially, especially during the last 20 years. Uncontrolled clearing of steep forest land to plant bananas and associated feeder road construction, uncontrolled construction of private and industrial buildings and a haphazard attitude towards the disposal of solid waste have all contributed the present potentially disastrous situation.

TSD in September 1994, brought with it untold devastation, but also a realisation that something was seriously wrong. The Island's vulnerability was again re-emphasised when heavy rain caused extensive damage in October 1996.

The post TSD World Bank Mission, proposed tackling the problem on a watershed basis. Logically, this makes sound sense, in that it brings together those who cause the problem with those who suffer the results. Such an approach also affords closer coordination of other interested institutions.

The Consultants were requested in their ToR to identify two watersheds for pilot study and subsequently, the preparation of their watershed plans. In close consultation with government, this was done at an early stage and Dennery on the east coast and Cul de Sac on the west, were chosen. Some characteristics are:

	Dennery	Cul de Sac
Area	21.4 sq. km	40.9 sq. km
Population (1)	2,918	12,806
Centres with population >300	2	13
Approx. number of banana farmers	250	600

While all the watersheds on the island have much in common, the pilot watersheds differ in that:

- Dennery is small and compact, has a highly homogenous population and virtually no flood plain. The main hazard during storm events is flooding of Dennery town, built on a low lying area close to the mouth of the river, and where protection works are a priority.
- Cul de Sac, with its 40.9 sq. km, is the third largest watershed on the Island, has a population over four times larger than Dennery, is located in 13 centres. It borders on Castries, the Island's capital, and has a growing industrial complex near the river mouth with associated river realignment and containment that could well cause problems. There are areas of high landslide hazard (Ravine Poisson) and extensive good banana plantations on the fertile floodplain.

6.2 LESSONS FROM PHASE 1 AND THE TRIALS PROGRAMME

6.2.1 Phase 1

The Phase 1 works and lessons learned are described in detail in Section 4.7 and summarised below.

Phase 1 was an emergency programme, to repair damaged infrastructure, drainage and river systems before the next rainy season. It was completed in good time at a cost of EC\$ 14.3 million, and involved mainly hard engineering works and some loop cutting in the rivers.

Engineering lessons learned were to:

- ensure that major infrastructure is designed to accommodate a 1:50 or 1:100 a year flood (not a year event);
- Minimise the degree of channel re-alignment particularly if it is purely to protect or create new agricultural land in the flood plain.

Possible improvements include:

- the introduction of palisading using natural materials for bank protection;
- the greater use of gabion mattresses but incorporating permeable membranes to reduce washouts of backfill material;
- the use of a greater variety of man-made materials which can provide the initial protection required to reduce new bank erosion whilst vegetation becomes established;
- the combined use of selected vegetation with gabions and rip rap to create a more permanent and effective structure;
- the need to link loop cutting, where such is seen as the only solution and to channel profile control measures;
- the importance of establishing a system for the regular inspection of the river system particularly at key infrastructure locations;
- the importance of regular maintenance tied to regular inspection of the channel and contact with local landowners or farmers:
 - keeping the channel clear of obstacles which will affect the flow regime;
 - reducing the danger of tall or overhanging trees from falling into or across the river channel by a defined system of top lopping;
- the identification of drainage system rehabilitation needs in the floodplain areas with tile assessment of the efficiency of the whole drainage system to the sea with consideration given to tidal level fluctuations in the lower areas. The re-excavation of field drainage ditches is an important factor in maintaining banana yields and quality in the face of potential waterlogging.

From an environmental perspective, the following observations were made.

- By necessity Phase 1 planning and implementation was undertaken in a hurry and time did not permit environmental assessments of specific detailed plans.
- The format of many of the Ph 1 detailed plans (1:1000 scale) is good, with existing riverbanks, areas/features of flood damage, existing trees, and recommendations for remedial works required being clearly shown. Widening of river channels was correctly specified to occur only on inside of river bends, with the maximum of bankside vegetation retained on the eroding outside bend.
- Planting of bankside trees should be specified as a top priority, a double row of trees on each bank being required. Planting of grasses, which was specified in many of the plans, and also implemented in most cases, is not sufficient alone to stabilise banks below 1m depth. Maintenance of trees should be the responsibility of the landowner, who should obtain any produce from the trees.
- Planting of grasses or leguminous cover crops should be undertaken on bare landsurfaces together with the above trees. Grasses and cover crops will be effective in the first few years in reducing soil erosion, but will eventually be largely shaded out by the more effective perennial trees. Vetiver (khus-khus) grass is a preferred species because it is not palatable and it has low maintenance requirements. Cattle should be kept well away from river bank areas.

- Making graded river embankments of unconsolidated transported material is likely to prove a failure, particularly where the river banks are more than 3m above bed level and not stabilised quickly by perennial, deep-rooting vegetation.
- Deepening of river channels below original levels is likely to lead to increased problems particularly river bank erosion. Any future cleaning of river channels should only be undertaken to original bed levels.
- Any future meander (loop)-cutting should not be undertaken except in exceptional circumstances (e.g. where current meanders are threatening major infrastructure over a wide area).
- Gabion baskets are highly effective at reducing bank erosion, but should only be used for protection of urban areas and essential infrastructure. Gabions should be further stabilised by placement of permeable membranes, and adjacent bank areas should be planted to trees. Gabions are generally favourable environmentally, providing habitats for fish and small aquatic animals.
- Heightening of banks in the lowermost parts of each valley reduce silt deposition in the floodplains, backswamps and wetland forest areas (including mangroves). Increased amounts of silt are then deposited in the sea. The lowermost part of floodplains should be kept under natural vegetation or rough grazing and allowed to flood. Further encroachment of these areas should not be allowed to occur, and likewise further raising of river banks/bunds in these areas should not be undertaken.

Although the above measures may be essential, contributory causes to peak flooding events should be appreciated. Major improvements can be made by better soil conservation measures, notably trash management in bananas, and by major planting programmes for perennial trees in place of in place of both bananas and annual crops on sloping land, particularly that over- 25 degrees.

6.2.2 Field Trials

Following the review of Phase 1, and based upon the lessons learned, a trials programme was designed.

The field trials comprised five main groups

- agronomic trials
- community participation
- river engineering trials
- bioengineering trials
- geotechnical/landslide trials

a) Agronomic trials

The trials, designed to show that various mulching treatments increase infiltration of rainfall thereby limiting run-off and other losses, have yielded encouraging results. Measurements of a two fold increase in infiltration on trash plots compared to bare soil have been recorded on most sites. Despite problems within the banana industry, it is unlikely that any rapid change in land use will take place and increased protection on banana plantings on steep land will make a significant improvement to soil conservation. There were two trials in each pilot watershed; at Pays Perdu and Glavier in Dennery and Chopin Ridge and Ravine Poisson in Cul de Sac. Substantial recommendations have resulted from these trials and form part of the management plans.

b) The Community Participation Trial - Dennery/Cul de Sac

Since the first public meeting in late January 1997, progress at Dennery has been good. A WMAF was formed, office-holders elected and regular meetings held. This has been well supported by AESD - which will later be formalised by the creation of a Watershed Management Unit (WMU) and

a Technical Operations Team (TOT) using existing government staff. Support has also come from MCWT&PU. Working together with the Community Participation Programme Coordinator a Master Plan has been prepared and prioritised. Small projects are currently being implemented locally. The rationale for starting this programme was that government, through reconvening the Land Conservation Board, would support the watershed-based WMAFs and give them proper authority. Sadly, this has not yet happened partly due to the recent change in government.

At Cul de Sac, a much more complex watershed, a smaller programme has been started. With limited time, funds and staff, it was decided to establish a sound working model (Dennery) rather than spread resources and do two job halves. However, much basic survey work has been completed and the process of sensitisation started. At a public meeting held on the 9th September 1997 attended by 40/50 people, much enthusiasm was shown. Further substantial development, the formation of a WMAF and detailing a Master Plan depends upon whether government is prepared to commit funds and staff to the programme.

c) River Engineering Trials

i) ENG 1 River Maintenance - Dennery River

Objective: To evaluate the mechanisms for the execution of a regular river channel maintenance programme.

This trial was included in the Dennery WMAF programme. The TOT together with MCWI'&PU staff have completed the physical inspection and reported to the WMAF for action. This was a trial survey and the experience gained will be applied elsewhere.

ii) ENG 2 Gabion protection - Cul de Sac

Objective: To improve on the overall structural integrity of gabion work through the minimisation of damage caused by the erosion of backfill through the application of improved engineering and bioengineering approach.

All engineering works have been completed but grass/ vegetation has not yet been planted. Early indications are that further minor works could be necessary in realigning gabion baskets and permeable membrane material should be located behind the gabion baskets.

iii) ENG 3 Road embankment protection from River Scour - Roseau/Cul de Sac

Objective: To establish a means of protecting a road embankment from the aggressive scour of a meandering stream using local labour and mainly local materials.

The works on this trial in the Cul de Sac Valley have been completed with the exception of the vetiver planting which is due to be undertaken in the near future. The earth coffer dam was overtopped and breached (22 June '97) but there was no drainage to the works as the gabion placement had already been completed almost to the top level.

The Mac-Mat soil protection is made up of steel wire with a loose fine plastic mesh cushion. This is not biodegradable although the plastic wires may eventually break-up leading to disintegration of the cushion. Biodegradable outer-based textiles are available and reportedly last about 2 to 4 years which would be adequate for vegetative growth to become well established.. This could be a preferable form of protection where aggressive flows are absent.

d) Geotechnical Trials

Four geotechnical trials were conducted at Ravine Poisson in Cul de Sac

iv) ENG 9 Landslide Hazard Warning System - Ravine Poisson

Objective: To initiate a long term study for a landslide hazard evacuation system for populated areas.

Ravine Poisson is an area with a historical record of landslides. Despite this, road and house construction has continued and the potential risk has increased. The site was chosen for the testing of a technology new to St. Lucia, using piezoi-meters. Vertical holes are drilled at selected locations and lined with special plastic tube. Readings are taken by inserting a probe, and a special computer programme is used to interpret data. Four sites have been drilled, judged to be sufficient for the area and to date no subsurface movement has been detected, but with the onset of the rainy season the trial will be monitored with interest. Additional Engineering time will cover future monitoring and training of AESD Technicians.

e) Bioengineering Trials

No bioengineering trials were conducted in the pilot watersheds, as the best sites were located elsewhere. However, two successful and encouraging trials located at Malout (watershed No 26) and Combat (watershed No 4) have demonstrated the validity of the techniques used.

6.3 SOCIO-ECONOMIC SURVEY

A socioeconomic survey, using rapid rural appraisal techniques was carried out in both of the pilot watersheds. It showed peoples perception of current problems as being:

- flooding is mainly due to deforestation and events like TSD were "Acts of God";
- land use was not seen as a cause of erosion on steep land;
- siltation and flooding in the lower valleys was seen as a result of neglect of maintenance of the rivers and drainage system.

This lack of awareness of cause and effect, highlights the need for public awareness campaigns, for technical guidance and the need to "seed" ideas at community level.

A check list that may well be used during sensitisation programmes is given at **Figure 6.1**.

Other relevant aspects of the socioeconomic background are:

The economy in general, including Dennery, is dominated by bananas. The industry in its broadest sense, provides employment for one in three of the population. The banana industry is changing, and marginal hillside growers, those targeted for a change to permanent fruit tree crops, are currently losing money. The strict rules applying to the "Certified Growers Scheme" will instigate further against them. A positive approach is essential, any change to annual crops on this land, would have disastrous consequences. Provision for this is built into the plan, with a demonstration plot (1 acre) using several tree species, and proposals are made to provide cheap credit to ease farmers through the first few years. This programme should be supported by a short consultancy, aimed at collating existing knowledge and experience, and filling any gaps. Also relevant, is the high level of unemployment in rural areas, estimated at over 20%, and the low employment opportunities especially for the many less well qualified. Any intervention in the banana industry must be handled with tact and thoughtfulness, if social unrest is to be avoided.

**Figure 6.1: Development of:
Dennery Watershed and Environmental Management Plan**

Component	Elements	Factors to Consider	Comments
Soil Conservation	On-farm Conservation Measures Crop Diversification Improved Agro-chemical usage Improve trash management Reduce Areas of exposed soil Feeder & other road management Better controlled on-farm drainage	How many farms in the Watershed? Map?	
		How many famers?	
		How to 'access' famers?	
		How to address issues with famers?	
		How to involve extension workers?	
		How to work as groups? Which?	
		What crops might be grown in place of bananas?	
		What incentives to change? What markets? Needs?	
		Use of sedimentation basins?	
		Are new roads planned? Why? Map?	
Who is willing to monitor runoff during storms?			
WASA Intake Catchments	Management of Activities Reduce/eliminate agriculture Reduce/resettle individuals Improve Management of Intake	How much agriculture there already? Map?	
		How many people live in the area? Map?	
		Who reports of supply problems? Keeps records?	
		What works could be done on the Intake? How to assist WASA?	
Solid Waste Management	Improve Garbage Collection Improve Agricultural Waste Control	What Problems currently exist?	
		Can better containers be used?	
		Can the kerbside sites be formalised?	
		Can kerbside sites be developed? Map?	
		Is some kerbside storage in flood prone areas?	
		Can Indiscriminate dump sites be identified?	
		Can glass bottle banks be developed? Where?	
		Can plastic bottle banks be developed?	
		Can less organic material enter the river? How?	
		Use of trash screen units?	
Can farmers have more control over 'blue plastic'?			
Dennery River Management	Removal of tree trunks, debris etc Regular Monitoring River strengthening	Who is responsible?	
		What is the impact of not doing anything?	
		How much local action can be expected?	
		Can bananas be kept away from river banks?	
		Does anyone irrigate from the river? Irrigate at all?	
		Can bio-engineering be used for bank stabilisation? Is the main bridge at risk from the River? What infrastructure is at risk from the river? Map?	
Urban Drainage	Improve Effectiveness Reduce Soild Waste Accumulation	What length of good drains need maintenance	
		Who is responsible? How effective is it?	
		Are any major new works required? Map?	
		Trash control? Removal?	
		What length of new drains are required? Where? What happens during high tides to the drains?	
Public Health Improvements?	Drinking Water Supply Septic Tanks/Pit latrines/ others	Is the current rate of new connections adequate?	
		Is the improvement in toilet facilities adequate?	
		Are there problems to be addressed? How? Who?	
Flood Proofing and Disaster Management	Improve existing infrastrcuture Improve Disaster Management Systems	What happens if the Flood Embankment overtops?	
		How many houses will be flooded? Which?	
		What can be done to reduce damage?	
		What changes can be put in place? Interest?	
		Are any 'Information Campaigns' necessary?	
		How active is the Disaster Management Committee?	
		What improvements are necessary?	
What warning systems are there? Improvements?			
Information Dissemination	General Public Schools	What campaigns exist? Have been done?	
		What campaigns are necessary?	
		What new campaigns are necessary?	
		What camplgns could be useful? How? Format?	
		- soil conservation?	
		- solid waste?	
		- flood risk?	
- crop diversification?			

6.4 AIR PHOTOGRAPHY, LAND USE AND EROSION ASSESSMENT

6.4.1 Small Format Air Photography (SFAP)

Lack of sufficiently detailed existing land use mapping was identified as a major constraint for any systematic planning of potential land use in the pilot watersheds. Work done for the CIDA Study (Roche Itee, 1993) was based on satellite imagery, and was insufficiently precise to differentiate the individual crop classes. Further work (1996-97) done by CEHI and the University of Kingston showed problems with the use of satellite imagery for such mapping, with a precision matrix showing that only 53% of areas were interpreted correctly. The Consultants' experience with even the very best satellite imagery elsewhere (combined LANDSAT TM with SPOT panchromatic, and Soyuz Imagery) shows that resolution of imagery very rarely justifies mapping at scales more detailed than 1:50,000.

Most importantly for watershed management, no map of land currently under bananas and seasonal crops was available for the island, and to undertake this, detailed aerial photography (> 1:10,000) would be required.

Conventional aerial photography of the last 15 years was available only for a small part of the pilot watershed areas (1993 1:14,900 mainly coastal areas), but no photography was available for the critical upper watershed areas. The Consultants thus undertook their own SFAP, using a local helicopter. However, due to persistence of bad weather, and due to logistics problems, aerial photography was possible only very late in the assignment (16 October 1997), and at a much lower elevation than ideal (2500ft), involving taking four times as many photos as originally planned. Time was thus not sufficient to complete routine mapping at this detailed scale for the entire area of the two watersheds. However, two substantial sample areas were completed in the Cul de Sac valley, and the usefulness of the technique was confirmed. Two sets of photos were acquired: vertical colour photography at approximately 1:4,500, and near vertical, colour stereoscopic photography at 1:7500 scale.

Full details of the SFAP are given in Annex 4 Chapter 3, including a flight diagram for the two sets of photography. Only the main conclusions from the work are presented here.

The photography proved very useful in giving up-to-date land use information, including differentiation of banana land into different classes in combinations with other crops. Individual tree crops could also be discerned in many cases. The standard of management of the land could also be interpreted. A detailed land use legend was thus devised (Table 6.1). An excellent view was also obtained on the status of construction in the areas covered, and the environmental problems that this was causing. Mass movement (landslide) features were also readily visible in the photos. The level of detail of the Land Cover/Land Use separation justified mapping at 1:7500 scale for most areas. With a small field size, and mixed land use, mapping at a smaller scale entailed loss of information.

The cost of the SFAP was some EC30 cents (7p) per acre including helicopter hire, films and processing for duplicate films. For interpretation of land of average complication, approximately 1 hour was required for detailed (1:4,500) interpretation of 100 acres. However, for hilly land, one further hour was required to transfer and adjust these boundaries to fit a controlled basemap. For valley bottom land, the work is simple and only 15-20 minutes was required. On the basis of work already undertaken, the consultants estimate that some 5 staff weeks would be required to complete the 1:7,500 mapping of the two pilot watersheds, and some 17 staff months would be required to complete the entire island.

6.4.2 Cul de Sac Watershed: Existing Land Use

The Land Use Legend used was a further refinement of the one used in the 1984 HTS study of the three major watersheds. Some 30 different subunits were recognised, of which 12 were banana land, including combinations of bananas with other crops. The estimated percentage cover of bananas within each unit was also given (see Table 6.1).

Three parts of the Cul de Sac Watershed were interpreted, and controlled maps at 1:7,500 scale were prepared for two of these:

- Lower Floodplain and adjacent areas (Figure 6.2);
- Ravine Poisson (Figure 6.3).

a) **The Lower Floodplain Area** is almost a text-book example of a suite of environmental problems. These are discussed in Chapter 4 of this volume (see also Figure 4.2 illustrating 1-major problems for this area). This area has been inappropriately zoned for industrial and commercial expansion, and the natural geomorphological and ecological functions of the lower floodplain have been by-passed. The result will be more silt in the sea causing problems both for the coastal ecology and the tourist industry. In addition the industrial and commercial properties will require very expensive foundations to cope with the difficult alluvial subsoil materials, and will be in very high flood-risk areas. Building in this area will worsen flooding in the otherwise excellent agricultural areas immediately upstream.

b) **Ravine Poisson** is an area of generally steeper slopes, and intense rural population pressure. Again inappropriately zoned construction is seen, in this case within rural settlement in ribbon development along the main highway and along the roads on Chopin Ridge. Of major concern here is the threat of landslides and mudflows, and one such event here in 1938 claimed the lives of 100 villagers. The area of the map extends from the area of steep primary forest beyond the southern end of the track, up to a point some 1100m north of the main highway bridge across the river, the proportion of forest remnants decreasing, and the proportion of rural settlement increasing, as one moves north.

For the Ravine Poisson map, areas of individual mapping units were measured. A spreadsheet was then devised to calculate areas of individual crops from the complex mapping units (Table 6.2). The lower part of the spreadsheet shows the proportions of the different crops in each complex, while the upper part works out the area of each crop in each mapping unit and thence the total area of each crop in the mapped area. Some 71 ha of bananas were mapped (i.e. 29% of the total area); of these some 33 ha were in pure stands while the remainder occurred in complexes with coconuts, other treecrops, or within complexes of mixed landuse. The proportions of the different crops or other land uses are shown in the pie chart, Figure 6.4. Of interest here is the fact that erodible land uses comprise 40% of the total landsurface; forest only 33%, and non-erosive agricultural (treecrops etc) some 27% of the land.

For comparison, the Central Cul de Sac sample area (see Interim Report; also Annex 4, Chapter 2) was also included here as Figure 6.5. Here bananas comprise 36%; forest only 12%, and non-erosive agriculture some 47%.

6.4.3 Cul de Sac Watershed: Identification of problem areas, and quantification of erosion risk

For the Ravine Poisson Area, areas of steep slopes in the classes >35, 30-35 and 25-30 degrees were obtained from the 1:1 0,000 topomap by use of a slope template, and these are shown in Figure 6.6.

TABLE 6.1: LAND COVER / LAND USE LEGEND: SMALL FORMAT AIR PHOTOGRAPHY (SFAP) SCALE 1:5,000-1:7,500

Unit Subunit Mapped	Description	% bananas	Estimated soil loss, t/ha/yr, for slopes of:					Remarks on current rates of erosion: (Applies to land under average levels of management)
			2deg	15deg	25deg	35deg	50deg	
1a	Rain Forest (broad leaved)		0.1	1	3	5	Most of erosion through Mass Movements.	
1b	Montane Thicket							
1c	Mangrove							
1d	Elfin Woodland							
P	Plantation Forest Species		0.2	2	6	10	Assumes long-cycle plantatns; select felling, good mmmnt.	
2	Secondary Forest / Logged + -enriched Primary Forest		0.2	2	4	7	Most of erosion through Mass Movements.	
3	Scrub Forest		0.2	2	6	10	Soils more highly erodible for these areas	
4	Open Woodland							
5	Grassland / Scrubland		2	20	60	100	Assumes some seasonal cultivation (c 20% of area / yr)	
5h	Wet Grassland (backswamps)							
6	Commercial Agricultural Lands (eg Estates)							
6b	V.intensive banana cultivation	90	7	14	40	60	(Assumes higher % of good land.& better level of mmmnt)	
6bf	- " -, v.young plant crop, or currently fallow	(0)	14	25	60	100	Deep drains in alluv.land show appreciable erosion	
6bc	- " -, interplanted with coconuts forming 15-50% cover	65	4	8	25	50	Ground cover commonly poor.	
6cb	- " -, interplanted with coconuts forming 55-80% cover	35	2	4	14	30	Some protn.from surface wash. little from mass movmtns	
6g	Grassland (generally hydromorphic)		1	4			Some protn.from surface wash. little from mass movmtns	
7	Intensive Small Farming						Permanent dense cover usual	
7b	Intensive smallholder banana cultivation	80	10	20	60	100	Deep drains in alluv.land show appreciable erosion	
7bf	- " -, v.young plant crop, or currently fallow	(0)	20	40	90	150	Ground cover commonly v.poor.	
7bc	- " -, interplanted with coconuts forming 15-50% cover	60	6	12	40	90	Some protn.from surface wash. little from mass movmtns	
7cb	- " -, interplanted with coconuts forming 55-80% cover	30	3	6	20	45	Some protn.from surface wash. little from mass movmtns	
7bt	- " -, interplanted with treecrops forming 15-50% cover	60	6	12	35	60	Treecrops give better protcn from mass movements	
7tb	- " -, interplanted with treecrops forming 55-80% cover	30	3	6	17	30	Treecrops giving good protcn from mass movements	
7m	Mixed smallholder cropping	50	5	10	20	75	Fair coverage by treecrops/perennials	
7tm	Mixed smallholder cropping dom.by treecrops	20	3	5	15	25	Treecrops giving good protcn from mass movements	
7t	Smallholder treecrops	0	2	4	12	20	Well established trees / complete ground cover	
7r	Seasonally cultivated and/or bare soil surface	0	40	90	200	500	Massive erosion, especially on steeper slopes.	
8	Mixed Small Farming							
9	Rural Settlement (houses, yards, and immediate houseplots)		6	12	40	90	Combines area of mixed cultivatn, plus high runoff area	
10	Urban, Periurban/Residential, Commercial, Institutional, Industrial							
10i	Industrial/Institutional		6	12	40		Combines area of mixed cultivatn, plus high runoff area	
10h	Residential / Homegardens		6	12	40	90	Combines area of mixed cultivatn, plus high runoff area	
10r	Disturbed Land (for buildings, roads)		90	200	400	900		

Complex Units include:

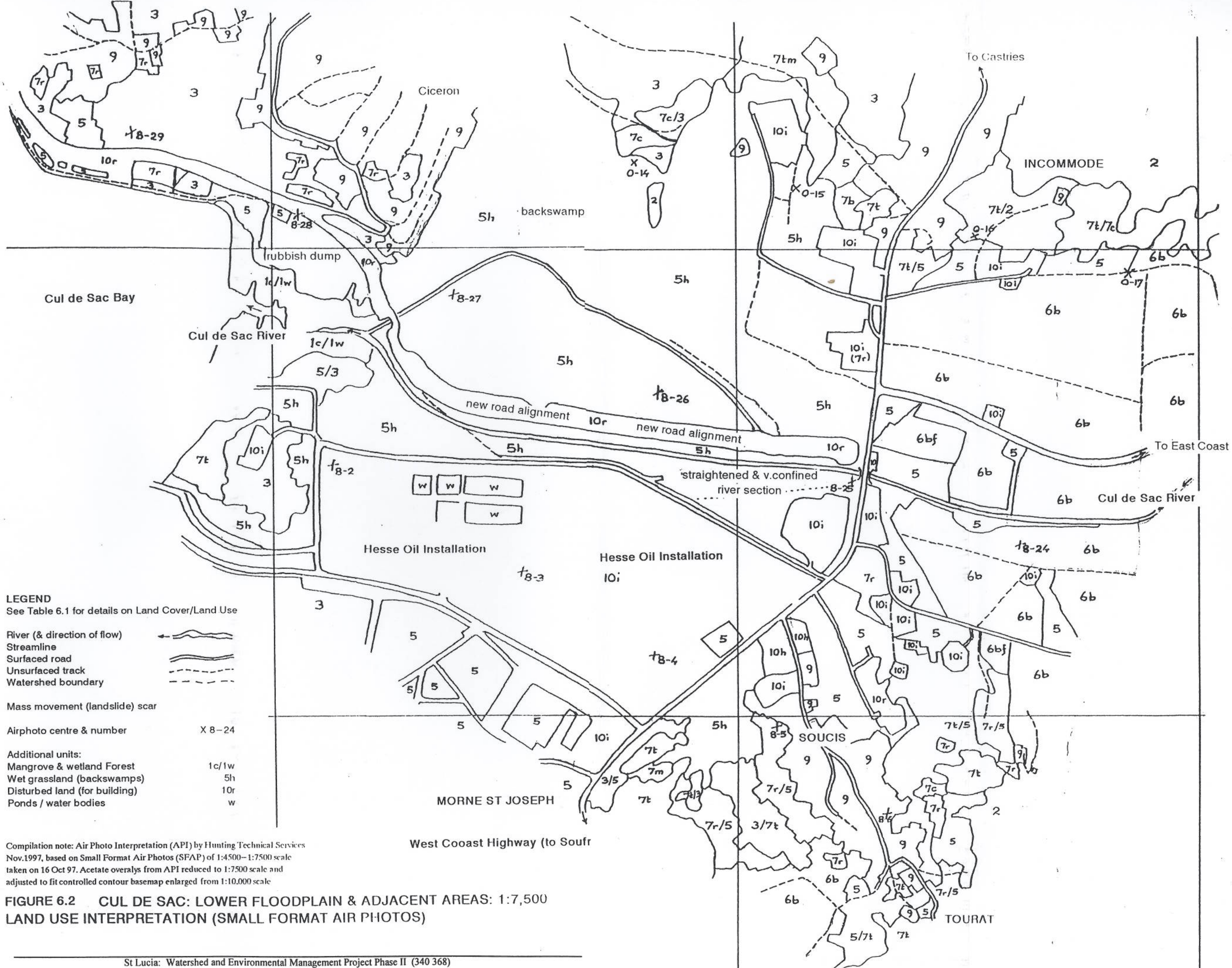
2/1; 2/7t; 5/7m; 5/7t; 7c/5; 7t/2; 7t/5.

Note: First unit in complex assumed to occupy 60% of area of the complex, second unit 40%.

Note: estimates on erosion include both surface wash and mass movements, averaged on yearly basis. Erosion estimates are of the Consultants, largely based on comparisons with: Hunting Technical Services Limited, June 1984. The Roseau, Denney, and Cul de Sac Drainage and Conservation Project.

LTS, RDC, HTS, March 97. Sri Lanka: Upper Watershed management Study (ADB PPTA). Land Resources, Land Use Planning, and Watershed Management Aspects.

Note: Above legend is an enlargement, with small modifications, of the Hunting Technical Services 1984 legend.



LEGEND
See Table 6.1 for details on Land Cover/Land Use

River (& direction of flow)
Streamline
Surfaced road
Unsurfaced track
Watershed boundary

Mass movement (landslide) scar

Airphoto centre & number X 8-24

Additional units:
Mangrove & wetland Forest 1c/1w
Wet grassland (backswamps) 5h
Disturbed land (for building) 10r
Ponds / water bodies w

Compilation note: Air Photo Interpretation (API) by Hunting Technical Services
Nov.1997, based on Small Format Air Photos (SFAP) of 1:4500-1:7500 scale
taken on 16 Oct 97. Acetate overlays from API reduced to 1:7500 scale and
adjusted to fit controlled contour basemap enlarged from 1:10,000 scale

**FIGURE 6.2 CUL DE SAC: LOWER FLOODPLAIN & ADJACENT AREAS: 1:7,500
LAND USE INTERPRETATION (SMALL FORMAT AIR PHOTOS)**

CUL DE SAC: RAVINE POISSON: LAND USE
 (ANALYSIS FROM 1:7,500 MAPPING ON SMALL FORMAT AIR PHOTOGRAPHY)

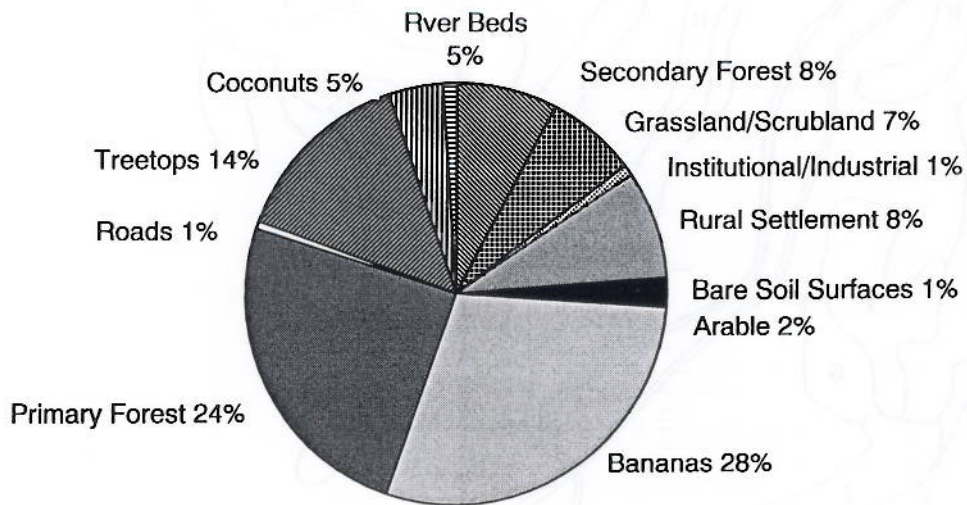


FIGURE 6.4

CUL DE SAC: CENTRAL AREA: LAND USE

(ANALYSIS FROM AIR PHOTO-INTERPRETATION OF 1992 PHOTOGRAPHY AT 1:c15,000 SCALE)

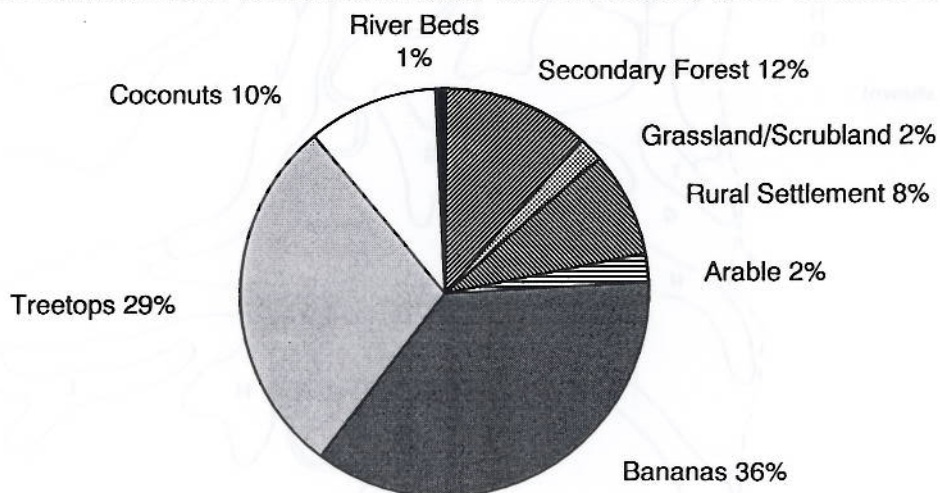


FIGURE 6.5

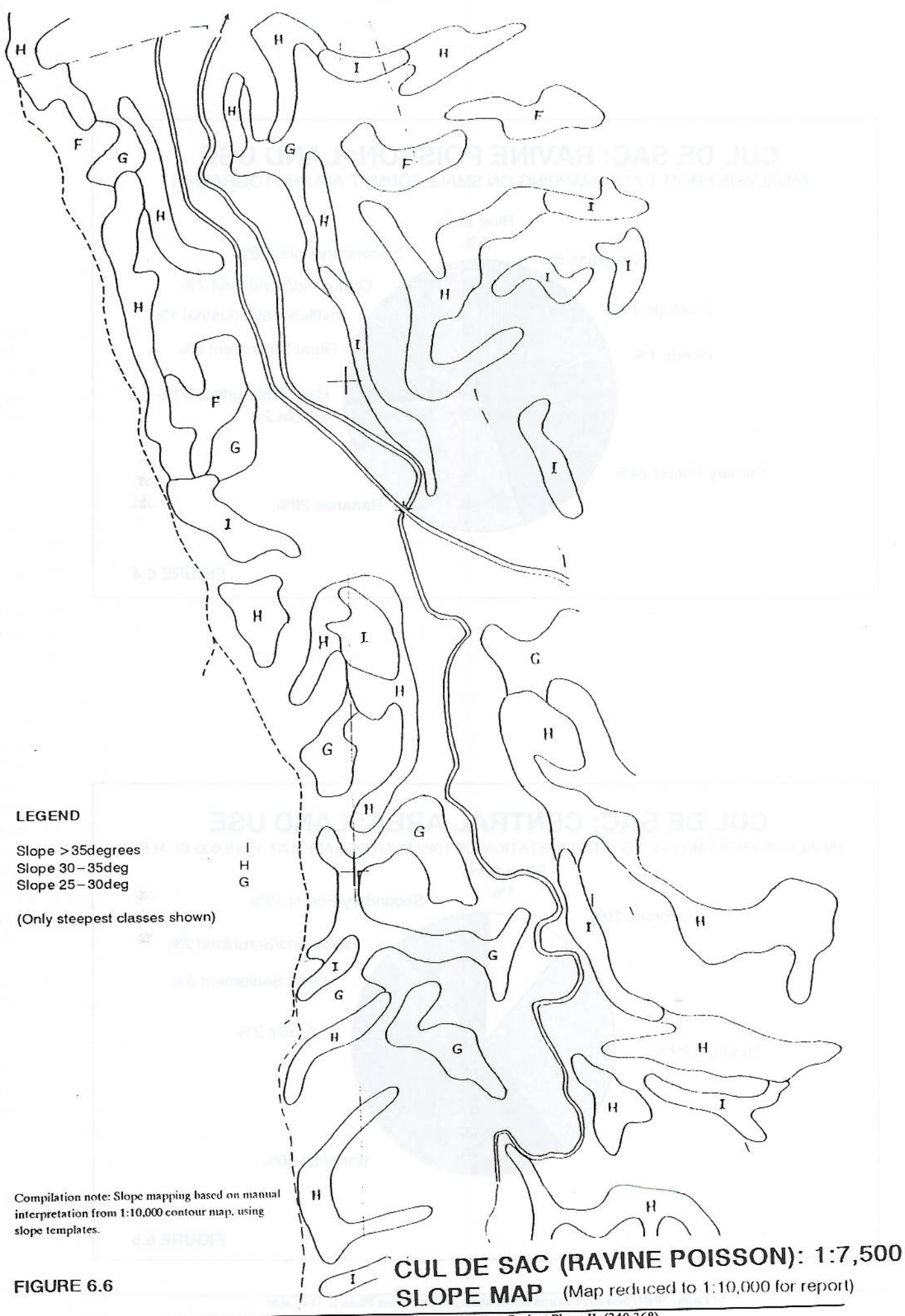


FIGURE 6.6

Estimates of erosion losses, through both surface wash, and mass movements were made from a compilation of a number of sources, notably:

- Hunting Technical Services, June 1984: the Roseau, Dennery and Cul de Sac Drainage and Conservation Project; 139
- LTS/RDC/HTS March 97: Upper Watershed Management Study Sri Lanka: here work done on measurements and assessments of erosion losses (and reservoir siltation) in the Mahaweli watershed areas was reviewed.

These estimates are shown for each land use subunit in **Table 6.1**. For the very steep land, (35 degrees slope) average losses over a long period are estimated to be between 5 tonnes/ha/yew. for Primary Rain Forest (losses occurring almost entirely in the form of infrequent mass movements) to some 1000 tonnes/ha/year for disturbed land (eg in construction projects). Smallholder banana land would show losses of some 100 tonnes/ha/year under the current poor levels of soil conservation and trash management.

By overlaying the slope map (**Figure 6.6**) with the detailed land use map (**Figure 6.3**), areas of high erosion hazard could be seen (**Figure 6.7**, reduced for the report to 1: 10,000). It is alarming that in the northern half of this map, a high percentage of the land is suffering from unsustainability high losses. The southern half currently shows relatively few erosion hotspots, due entirely to less banana cultivation. It is important here that agricultural feeder roads are riot extended further into the area.

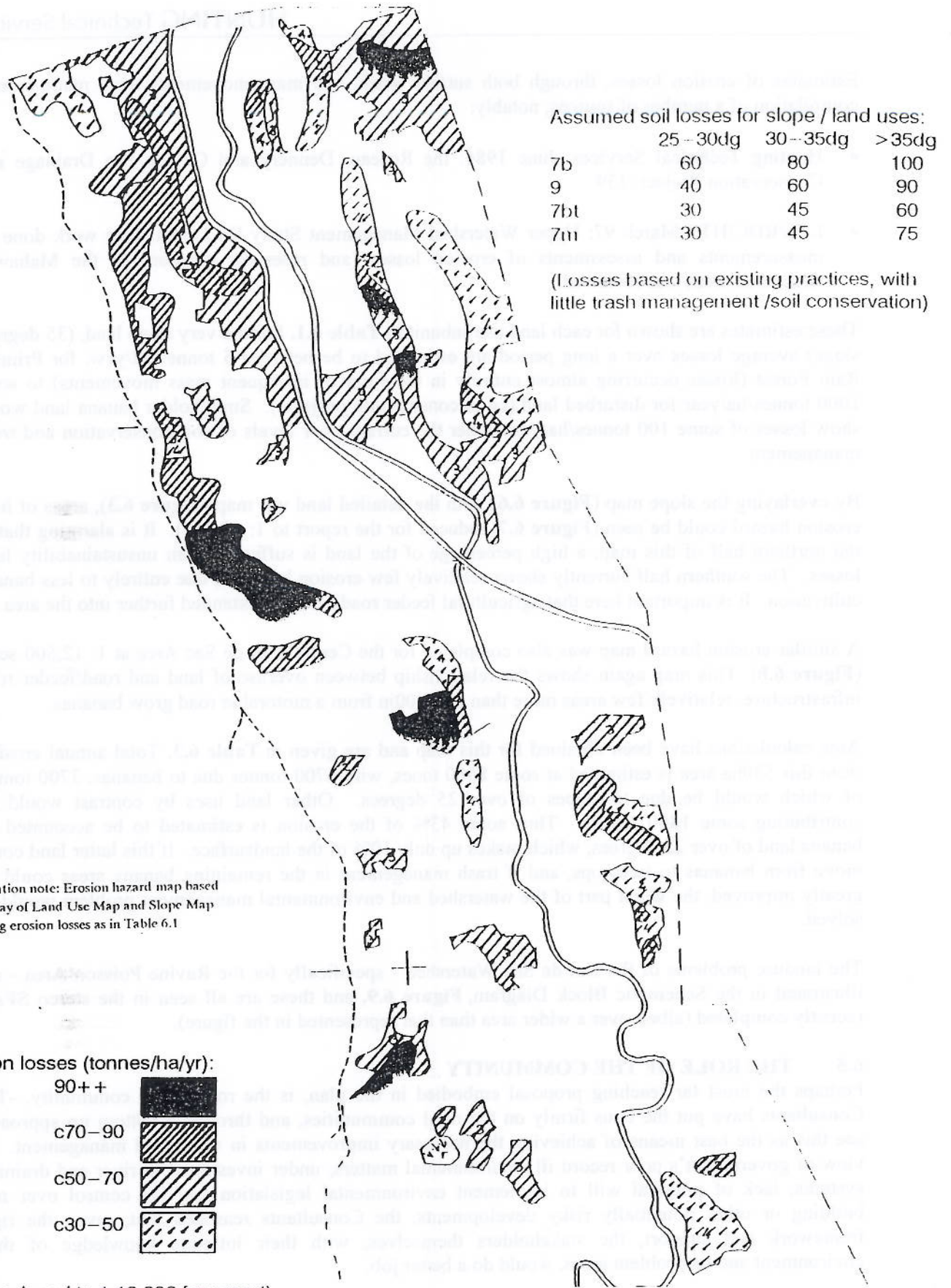
A similar erosion hazard map was also completed for the Central Cut de Sac Area at 1: 12,500 scale (**Figure 6.8**). This map again shows the relationship between overuse of land and road/feeder road infrastructure: relatively few areas more than 300-400in from a motorable road grow bananas.

Area calculations have been obtained for this map and are given in **Table 6.3**. Total annual erosion from this 530ha area is estimated at some 8500 tones, with 6700 tonnes due to bananas, 3700 tonnes of which would be due to slopes of over 25 degrees. Other land uses by contrast would be contributing some 1800 tonnes. Thus some 43% of the erosion is estimated to be accounted by banana land of over 25 degrees, which makes up only 10% of the landsurface. If this latter land could move from bananas to treecrops, and if trash management in the remaining banana areas could be greatly improved, the worst part of the watershed and environmental management problem would be solved.

The landuse problems of the Cul de Sac Watershed - specifically for the Ravine Poisson Area - are illustrated in the Schematic Block Diagram, **Figure 6.9**, and these are all seen in the stereo SFAP recently completed (albeit over a wider area than that represented in the figure).

6.5 THE ROLE OF THE COMMUNITY

Perhaps the most far reaching proposal embodied in the plan, is the role of the community. -The Consultants have put the onus firmly on the rural communities, and through a bottom up approach, see this as the best means of achieving the necessary improvements in watershed management. In view of government's poor record ill environmental matters; under investment in river and drainage systems, lack of political will to implement environmental legislation and lax control over new building or other potentially risky developments, the Consultants reasoned that, given the right framework and support, the stakeholders themselves, with their intimate knowledge of their environment and its problem areas, would do a better job.



(Map reduced to 1:10,000 for report)

CUL DE SAC (RAVINE POISSON): 1:7,500 EROSION HAZARD

FIGURE 6.7

Dennery watershed was and still is, the location of the projects one and only full community participation programme. The idea was received, from the outset, with enthusiasm and the first ever Watershed Management Action Force was formed early in the year, and with the support and encouragement of the Community Participation Coordinator and a Technical Operations leans, very good progress has been made.

6.6 LESSONS LEARNED FROM THE DENNERY CPP

The need for a community based approach is covered in Section 382 whilst the main features of the project are contained in 3.8.3.

Community Participation, especially in a country like St. Lucia which lacks a deep-rooted history of community responsibility and empowerment, is a long process and needs an extended start-up period. Once the official trial period for the Community Participation Programme is over, i.e. by December 1998, a real assessment will be possible, however, a few lessons and conclusions can be drawn at this early stage.

i) It has become apparent that government, and the communities themselves are coming to appreciate the potential of community involvement in the protection of natural resources and other areas of social and economic development. Through the efforts and support of the personnel of the participating ministries, it has become evident that government is moving towards the recognition that community participation not only improves the chances of a project's success but perhaps that community participation is a human right in itself - the right and responsibility of people to take charge of their own lives and to become involved in the process of projects which affect their interest and livelihoods. The trial has begun to introduce new ways of addressing practical issues which will go a long way in assisting the members of the Dennery communities to become more aware of their choices and their ability to determine priorities.

ii) As with most similar participation programmes, helping communities and organisations to take control of their (natural) resources is not a process which occurs overnight but takes time and patience. It requires a drastic change in attitude, behaviour and time to allow people to develop new thoughts, skills and knowledge based on critical reflection on the realities of, and constraints on, their particular economic and social environment.

iii) The people's understanding of what community participation really means has been shown to be limited or incorrect. At the beginning of the programme there was a view that the community (through the WMAF) would be willing to cooperate in problem identification and the elaboration of recommendations as to how to overcome these problems, but that the execution of the necessary work was the project or the government's concern. Furthermore, the WMAF initially focused exclusively on project (works) proposals which entailed to a large extent the involvement of MEWT & PU (e.g. desilting of the river mouth) and where no direct involvement of the community was needed (in terms of works execution). Although these more spectacular projects" can impress people and are important to promote the WMAF, real community mobilisation and participation starts and consists of activities which are mainly carried out by the members of the community based group and the wider community, and which require a limited if any budget. Furthermore, the time-lag between the identification of more complex and technically demanding projects and the actual execution is long whereas smaller community based activities require little time to organise. It is therefore imperative to concentrate in future replications of the Dennery experience on these "simple" projects and activities, especially in the start-up phase of an WMAF.

CUL DE SAC SAMPLE AREA: 1:12,500

TABLE 6.3

L.U.Unit:	6b	7b	7m	7cm	7tm	7t	9	2/7t	Erosion Risk Areas					Total
									100	80	60	40	25	
Areas of Land Use Units (ha)	13.6	6.8	7.3	9.6	14.4	7.4	5.7	19.5	0.6	4.1	8.2	0.4	0.5	100
% Area	72.0	46.6	38.4	50.6	76.3	38.3	30.2	103.3	3.0	21.9	43.1	2.2	2.5	529
Hectares														
Estimate of Mean Erosion/Year														
Eros(t/ha/yr)	14	20	10	6	5	4	12	2	100	80	60	40	25	
Tonnes erosion/Yr	1008	931	384	304	381	156	362	207	297	1750	2588	87.5	62.5	8513
% of Erosion	11.8	10.9	4.5	3.6	4.5	1.3	4.2	2.4	3.5	20.5	30.4	1.0	0.7	
Estimate of Net Areas of Bananas (Ha equivalent)														
%bananas	90	80	50	30	20	0								
Hectares equiv.	64.8	37.3	19.2	15.2	15.3	0								195

Breakdown of Erosion Risk Areas (& deg.slope):	7b					9						
	>35	30-35	25-30	>35	30-35	25-30	>35	30-35	25-30	>35	30-35	25-30
	0.4	3.5	5.2	0.1	0.6	1.9	100	80	60	100	80	60
	2.3	18.6	32.8	0.6	3.3	10.3	284	1488	1969	63	263	619
							2.3	17.5	23.1	0.7	3.1	7.3
							80	80	30			
							1.9	14.9	26.3			

Estimate of Erosion (tonnes/yr) attributable to: Bananas: 6700 Other Land Uses: 1813
 Bananas on slopes >25deg: 3691

Note: High erosion - risk areas include mainly 7b (bananas) and 9 (Houseplots) on slopes of >25deg.

FILE:VAREAC.AWK3

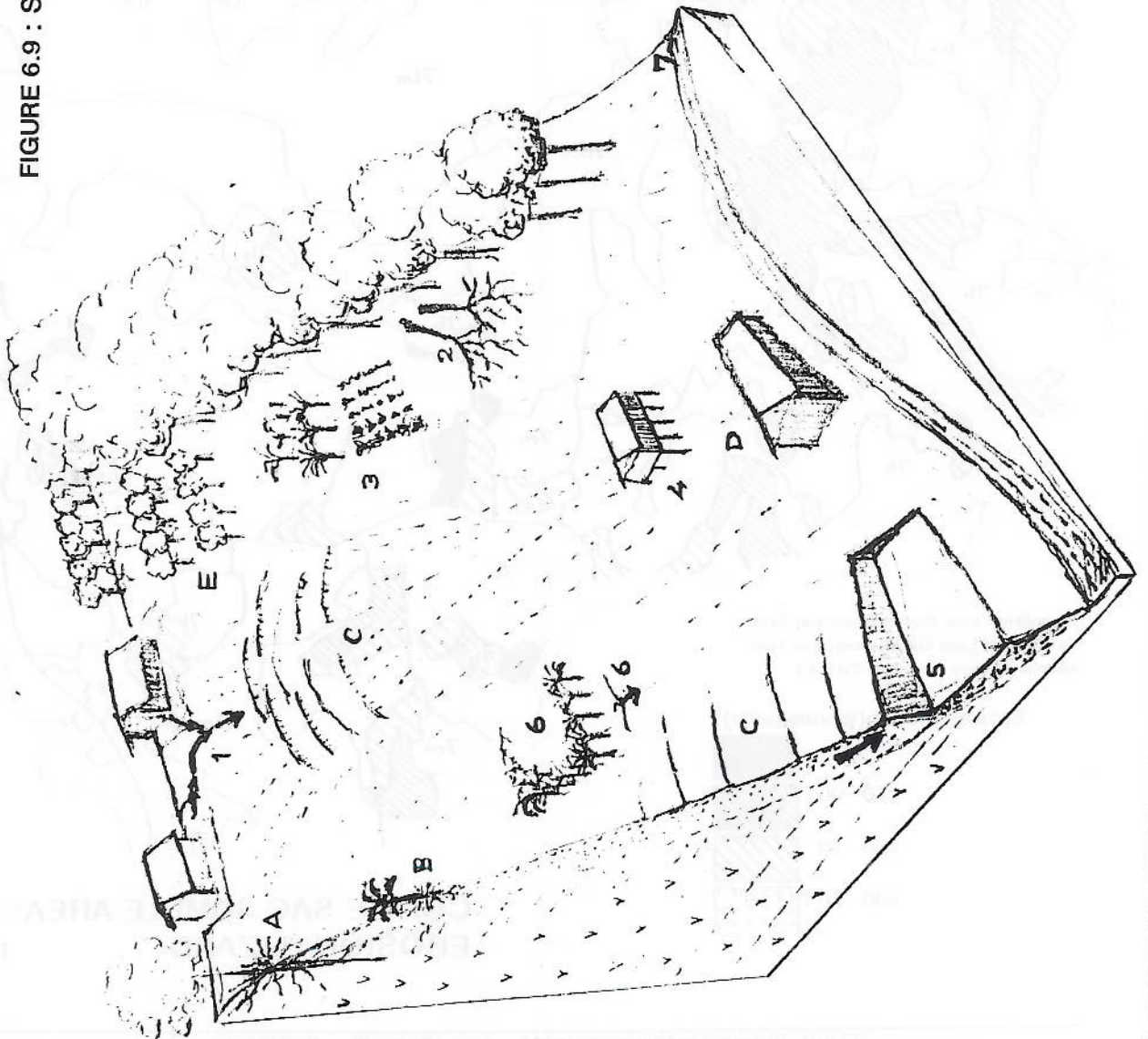
FIGURE 6.9 : SCHEMATIC BLOCK DIAGRAM: RAVINE POISSON AREA

Factors increasing risk of Mass Movements (Landslides): (1 to 7):

1. *Building along ridge – line (adjacent steep slopes): producing concentration of drainage water from roads and houseplots*
2. *Removal of forest vegetation which was anchoring soil to bedrock*
3. *Cultivation of seasonal crops – ground provisions – and bananas (cultivation and paths wrongly run up – and – down slope)*
4. *Siting of buildings on steep slopes*
5. *Base of slope further de – stabilised by cuttings for roads & houselots*
6. *Banana cultivation: poor trash management: extra run – off of water, subsequently infiltrating in areas of incipient cracks on steep slopes*
7. *Feeder road construction opening up new steep areas to encroachment, deforestation and inappropriate agricultural use*

Other features to note:

- A. *Well – established tree: deep taproot and dense, strong network of surface roots anchoring soil to firm bedrock*
- B. *Banana rooting: network of surface roots, but less strong, and complete lack of deep taproots*
- C. *Cracks and terracettes formed by incipient mass movements: major landslide quite probable here during next TSD – type rainfall*
- D. *Buildings under threat from burial by landslide materials*
- E. *Better land use practice: underplanting of bananas on sloping land (20 – 30deg) with fruit – trees: close spacing on contour (eg 12ft) – wider spacing between contours (eg 24 – 30ft). Bananas to continue as nurse crop for 3 – 4 years.*



iv) As may be expected, community spirit is often lacking, especially when personal gain rather than benefit to the community as a whole is involved. For example, farmers who recognise that poor farming practices such as cultivation on steep hillsides without proper soil conservation contribute to the process of degradation find it difficult to change. For such farmers it is difficult to look beyond their own need to provide a livelihood for themselves and their families to the social (and long-term economic) good of the entire community or country.

Bananas are likely to be the dominant crop for the foreseeable future and much better soil conservation practices are readily achievable in banana fields through efficient trash management.

v) Many community members are still reluctant to give time and effort to the programme. This general scepticism derives from the fact that people are generally wary of government, community and other projects or programmes which typically promise some sort of relief from one form of hardship or the other but which have shown no continuity or tangible results. Some community members are discouraged and cynical despite their understanding of the potential benefit of the programme. This situation limits the level of community involvement in the process of implementation, as some persons despite their knowledge are for now content to hand over their participation rights to the WMAF rather than become actively involved in the process.

To overcome people's scepticism and reluctance towards such programmes will require serious long-term commitment on the part of the government and from the members of the respective WMAFS. Care should be taken not to raise community expectations to a level beyond the implementation capacity of the programming.

vi) Strong leadership of a WMAF is of vital importance to the sustainability and the success of the group and the CPP as a whole. It is essential that the WMAF be led by strong, dynamic, enthusiastic and community oriented chairpersons and executive members who have the ability and skill to direct and mobilise community interest and effort. The Dennery WMAF has been fortunate in being led by a chairperson and deputy who are both well known and actively involved in other community organisations and affairs, very careful consideration must be given to leadership choices.

vii) It is important that any newly established WMAF be given physical identity through the provision of a proper office from which it (and the TOT) can operate.

viii) For the sake of the communities and the success of the community participation programme careful selection is necessary with respect to the CPP- Coordinator and the officers of the Technical Operations Team.

There are no doubt more lessons to be learnt, but even at this early stage, a good start with community development should be possible in the more complex lieterogenous community of Cul de Sac. The basic steps to be taken in establishing the CPP are:

- Reconnaissance Exercise/Surveys;
- Inception Meetings and Initial Sensitisation;
- Establishment of an 'Interim' WMAF;
- Sensitisation and Publicity Campaign;
- Establishment and first meeting of the WMAF;
- Appointment of Technical Operations Team (TOT);
- Identification of External Support Groups;
- Participatory Problem Identification and Prioritisation;
- Participatory Preparation of WMAF Work Plan;
- Participatory Project Planning and Prioritisation;

- Implementation of Priority Projects/Activities;
- Participatory Monitoring;
- Participatory Evaluation;
- Internal Education Programme for the WMAF and TOT.

6.7 THE PRINCIPLES OF WATERSHED MANAGEMENT

While there are of course differences between the conditions in the island's watersheds there are also many important common problems. Through their studies over the past 14 months, the Consultants have listed these, in **Table 6.4**. These points form the basis of watershed plans, drawn up by the respective WMAF. Initial surveys should be aimed at quantifying the problem areas and once this has been accomplished, prioritisation should be relatively easy. Not all problems can be solved at once, constraints of time, personnel and funds must all be taken into account. In Dennery, much of this has already taken place, and a Master Plan has been produced. From this the first annual plan has been derived, and the cost is included in Chapter 8. It must also be realised that plans need to be flexible and priorities may well change as the WMAF gains experience.

Based largely on the Dennery experience, together with experience from Cul de Sac and to a lesser extent from the other watersheds, a bar chart showing scheduling of the activities outlined in **Table 6.4** has been devised, and this is presented as **Table 6.5**. Some 63 individual activities are listed, under eight major subject headings: General; Land Conservation; River System Management and Monitoring; Infrastructure Risk Assessment and Protection; Solid Waste Management; Water Resource Utilisation; Development Planning and Control, and Education and Publicity. The listing is for a typical watershed, and assumes a start of activities in early January - i.e. the start of the Dry Season. For a start at another time of the year, rescheduling of some activities may be necessary, as they may depend either on drier conditions (e.g. for SFAP, and River System Management) or wetter conditions (planting programmes). The importance of the activities differs between different watersheds- e.g. WASA intakes are present in only certain watersheds - and overall some activities will be very much more important than others. Solid Waste management, for example, is being covered very comprehensively at the moment by other programmes, and it is important that any activity in this field complements those programmes. For this reason activities on Solid Waste Management have been scheduled mainly for month 9 and later. In each watershed, attention must be immediately focused on mainstream activities, notably Land Conservation, River Systems and Water Resources.

6.8 THE IMMEDIATE PROGRAMME FOR DENNERY

The programme in Dennery can be deemed to have started in January 1997, and it is important to make provision for its continuation until the Consultants' proposed programme starts in April 1998. Important aspects of this period are:

- the continued employment on temporary terms of the CPP Coordinator until a permanent position is established;
- the TOT should continue in their supporting role using the balance of funds available during the current financial year;
- Government should take speedy action in re-establishing the LCB to lend essential authority to the WMAF;
- survey work, including further interpretation of the SFAP must continue, in order to build up the data base;
- internal education and sensitisation programmes should continue;
- funds should be made available through AESD during the current year, to allow the WMAF to make a start with some meaningful activities (river bank planting, repairs to drainage/culverts etc). In addition to performing useful work, the experience in handling funds and letting small contracts is an essential element of the trial, which will yield valuable experience for use during the extrapolation programme.

TABLE 6.4

Issues	Approaches	Actions
<p>LAND CONSERVATION PROGRAMME</p> <ul style="list-style-type: none"> ◆ Soil Erosion (Surface Wash) & Flash Runoff in steeply sloping Banana Lands 	<ul style="list-style-type: none"> ◆ On-farm Trash Management ◆ On-farm Surface Drainage Improvements 	<ul style="list-style-type: none"> ◆ Establish and maintain uniform cover of banana trash. Trash to be aligned on contour forming uniform cover. Pseudostems to be split longitudinally. ◆ Establish and maintain banana trash lines on contour. Glyricidia nurseries/plantings to provide stakes require to be set up. ◆ Tied Contour Drains to be installed: ties to be open in wet & closed in dry seasons. Much care needed on land susceptible to landslides. ◆ Stone-lined or staked, stepped drainage & gully plugs, needed for control of gulleying in threatened areas only. ◆ Integration of gulley/path drainage and some houseplot drainage with farm drainage.
<ul style="list-style-type: none"> ◆ Soil Erosion (Surface Wash) in Deep Surface Drains in Flat (Alluvial) Banana Lands 	<ul style="list-style-type: none"> ◆ On-farm Trash Management 	<ul style="list-style-type: none"> ◆ Establish and maintain uniform cover of banana trash ◆ Establish and maintain banana trash lines towards base of surface drain.
<ul style="list-style-type: none"> ◆ River-bank erosion 	<ul style="list-style-type: none"> ◆ Retention of 10m River reserve 	<ul style="list-style-type: none"> ◆ Facilitate weed cover on drain sides: clean drain bottoms only. ◆ Plant and maintain double row of trees along river banks: most urgent in concave (eroding) banks. Include fruit & timber species. ◆ Plant and maintain cover crops in bare soil areas. Rapid establishment after stumping is essential. Ban grazing of animals.
<ul style="list-style-type: none"> ◆ Soil Erosion (Surface wash) in steeply sloping annual cropping land 	<ul style="list-style-type: none"> ◆ Monitor problem carefully ◆ Legislation/(?taxation) ◆ Provision of foodgarden plots ◆ Education of farmers ◆ Alternative cropping 	<ul style="list-style-type: none"> ◆ Updated land use survey: SFAP. Problem likely to get much worse. Restrict annual crops to slopes of <15deg: introduce legislation, based on examples from other countries. ◆ provision of 0.2-0.5acre plots in flat areas: establishment of land bank for redistribution of under-utilised land. ◆ WMAF programmes: emphasise cost of flash flooding and siltation to downstream land users, and to tourism etc. ◆ Promote alternative treecrops: information required on prices & marketing; organisation of consolidation for sea shipment ◆ Introduce and undertake trials on new 'Asian fruits': mangosteen, litchis, rambutans, durian, jak.
<ul style="list-style-type: none"> ◆ Mass-movements (Landslides) on steep agricultural land 	<ul style="list-style-type: none"> ◆ Underplanting (& eventual replacement) of bananas by deep-rooted trees (all cultiv. land of > 30deg slope) 	<ul style="list-style-type: none"> ◆ Cocoa, combined with glyricidia shade and windbreaks. shade & windbreaks ◆ Coconuts: retention and care of all existing trees: planting dwarf hybrids (water nuts) on contour. Rehabilitation of oil mill needed. ◆ Promote alternative treecrops: underplant steep banana land to avocados, breadfruit, mangoes, citrus, grown on contour. ◆ Timber - tree planting required on steepest land including long-cycle plantations and mixed plantings of green mahoe, mahogany

TABLE 6.4(CONT)

Issues LAND CONSERVATION PROGRAMME	Approaches	Actions
<ul style="list-style-type: none"> ◆ Land Policy & Control of Encroachment 	<ul style="list-style-type: none"> ◆ Education/Local Participation ◆ Eviction in priority areas ◆ Possible Landbank Programme ◆ Rationalisation of land taxation and registration 	<ul style="list-style-type: none"> ◆ Listing of priorities for Action: encroachment to be tackled first in environmentally most damaging areas. ◆ Discussion and educational programmes at WMAFs ◆ Evictions in areas above WASA intakes, in/near conservation areas, or areas of high landslide risk. ◆ Expropriation/redistribution of unused / misused land. ◆ Redistribution of unused government land (some high-value land available) ◆ Introduction of taxation of land proportional to environmental costs: tax credits for environmental benefits (eg for forestry)
<ul style="list-style-type: none"> ◆ Agro-chemical overuse/misuse 	<ul style="list-style-type: none"> ◆ Liming to combat acidification due to heavy use of NPK fertilizer ◆ Overuse of high K banana fertilr. in some non-banana crops ◆ Minimise fertilizer losses on slope ◆ Overuse/eratic use of nematicide ◆ Minimise hot-spots for pesticide accumulation 	<ul style="list-style-type: none"> ◆ Survey of problem-pH nutrient balances; organisation & bulk import of cheaper sources of agricultural lime. Advisory notes to be compiled for farmers. ◆ More use of soil analysis; provision of appropriate fertiliser mixtures for different crops, and advice on correct fertiliser. ◆ Development of fertilizer injector, adapted from current pesticide soil injector. ◆ Balanced nematicide applications required in relation to other inputs. ◆ Introduce crop rotation with bananas on flat land:French islands exp ◆ Research on biological control: nematode trapping fungi and nematode-repelling plant exudates. ◆ Supervision of banana sheds, farm buildings and adjacent drains
<ul style="list-style-type: none"> ◆ Banana Monocropping/ Crop Diversification 	<ul style="list-style-type: none"> ◆ Promote annual cropping in flat & gently sloping land; ◆ Bananas and underplanted tree crops on sloping land (particularly >20/25deg) ◆ Forest plantations for steepest land (most >30, all >35deg) 	<ul style="list-style-type: none"> ◆ Dry areas, dry season: irrigation with high value seasonal crops, eg melon, watermelon, tomato, chillies, capsicum, vegetables. ◆ Other areas, most seasons: cultivation of rootcrops & vegetables of rootcrops, vegetables ◆ Cocoa, combined with leguminous shade tree & windbreaks ◆ Coconuts:retention & care of all existing trees; new plantings to be dwarf hybrids, planted on contour ◆ Fruit tree perennials on contour: mango,avocado, breadfruit, citrus. ◆ Timber-tree planting on steepest land: new species to be tried including jak.

TABLE 6.4(CONT)

Issues: DRAINAGE SYSTEM IMPROVEMENTS	Approaches	Actions
<ul style="list-style-type: none"> ◆ Problems in the performance of the River Network including poor conveyance and flooding, and causing risk to infrastructure 	<ul style="list-style-type: none"> ◆ Major river training works ◆ Regular river channel maintenance 	<ul style="list-style-type: none"> ◆ Regular river channel surveys to monitor the river network and identify constriction areas or infrastructure at risk. ◆ Monitoring the performance of cross drainage structures and identifying blockage possibilities. ◆ Introduction of gabion protection works with associated bio-engineering works to protect vulnerable infrastructure e.g. roads, service lines etc. ◆ Undertaking regular river maintenance through removal of accumulated dead vegetation, particularly trees, bushes and banana stems. Trimming or removal of overhanging trees ◆ Introduction of bio-engineering works to provide protection to vulnerable river banks. ◆ Cutting back of steep sided banks and protecting from further undercutting (soil removed rather than being left to erode into the river flow).
<ul style="list-style-type: none"> ◆ Trash and sediment emanating from outflows from on-farm drainage 	<ul style="list-style-type: none"> ◆ Sediment control systems ◆ Trash control systems 	<ul style="list-style-type: none"> ◆ Provision of spill areas during high flood events. Water holding areas can be created by throttling the drainage system causing flooding and sediment and trash retention at farm level. Water holding area to be grassed to minimise erosion. ◆ Potential for inclusion of trash screens at the outlet from farm units prior to discharge to the river network. Trash screens to be maintained by the farmer.
<ul style="list-style-type: none"> ◆ Waterlogging caused by deficiencies in agricultural drainage 	<ul style="list-style-type: none"> ◆ Provision of well designed drainage system ◆ Monitor water table position and yield distributions 	<ul style="list-style-type: none"> ◆ Undertake design of the complete drainage network based on topographic survey information. ◆ Recommend modifications to the existing drainage system and means of implementing the required works. ◆ Establish annual maintenance programme to set drain section criteria and establish implementation process (scheduling, activities, provision of labour). ◆ Incorporate erosion/ sediment control features within the system.
<ul style="list-style-type: none"> ◆ Flooding and environmental problems caused by inadequate Urban Drainage Systems 	<ul style="list-style-type: none"> ◆ Improve design and construction standards ◆ Improve maintenance procedures 	<ul style="list-style-type: none"> ◆ Review existing drainage system with topographic surveys and discharge estimates. ◆ Assess extent of the drainage congestion problem caused by garbage and element caused by inadequate capacity. ◆ Upgrade drainage channels where necessary and enlarge/introduce cross drainage culverts. ◆ Establish programme for regular, systematic, supervised channel maintenance.

TABLE 6.4(CONT)

Issues: INFRASTRUCTURE RISK ASSESSMENT AND PROTECTION	Approaches	Actions
<ul style="list-style-type: none"> ◆ General Risk 	<ul style="list-style-type: none"> ◆ Infrastructure Inventory ◆ Regular Monitoring Programme 	<ul style="list-style-type: none"> ◆ Undertake infrastructure survey identifying risk to the integrity of the structures from different potential causes of damage. ◆ Undertake annual review of the inventory with recommendations for risk reductions for specific structures or facilities. Assess cost implications of proposed programme.
<ul style="list-style-type: none"> ◆ River Erosion Risk 	<ul style="list-style-type: none"> ◆ River Surveys near Infrastructure [roads, bridges, electricity and telephone lines, buildings and recreation facilities] 	<ul style="list-style-type: none"> ◆ Identify shifts or movements in river alignments and the impacts on infrastructure. ◆ Identify channel obstructions causing river movement and remove (Drainage Action). ◆ Identify and implement river training or bank protection requirements to reduce risk. ◆ Identify instances where the modification or replacement of the infrastructure would be a more viable solution. Bring to the attention of the relevant authorities. ◆ Identify and implement bio-engineering works which might pre-empt further river movement which might lead to damage to infrastructure.
<ul style="list-style-type: none"> ◆ Land Slide Risk 	<ul style="list-style-type: none"> ◆ Monitoring and Warning Systems ◆ Engineering Works to reduce risk 	<ul style="list-style-type: none"> ◆ Install geotechnical monitoring equipment in high risk areas where significant advance warning is necessary. ◆ Place road signs in areas where landslide slippage poses a risk; ◆ Undertake regular programme of public awareness campaigns as to the dangers of landslides and the identification of 'tell-tale' signs (poles or trees changing their inclination, small slips on a greater potential slip surface). ◆ Undertake slope stabilisation programmes (bio-engineering or other) in key landslide hazard areas. ◆ Undertake programme of vegetation control on high risk slopes, reducing heavy vegetation coverage (lopping) yet maintaining root systems
<ul style="list-style-type: none"> ◆ Flood Risk - fluvial 	<ul style="list-style-type: none"> ◆ Monitoring and Warning Systems ◆ Engineering Works to Reduce Risk 	<ul style="list-style-type: none"> ◆ Introduce into main habitation areas a flood level indicator pole; ◆ Incorporate flood risk assessment into the planning process - developers aware of risk ◆ Broadcast flood risk warnings based on rainfall intensities and antecedent conditions ◆ Awareness campaigns of impact of poor river maintenance, debris and solid waste management n flooding and the impact of floodwaters. ◆ Build low height protection bunds to protect buildings in floodplain ◆ Undertake flood-proofing of buildings (move electrics, modify drainage systems etc)
<ul style="list-style-type: none"> ◆ Flood Risk - tidal 	<ul style="list-style-type: none"> ◆ Monitoring & Warning ◆ Engineering Works 	<ul style="list-style-type: none"> ◆ Broadcast high tide and potential surge warnings and potential impacts ◆ Incorporate flap gates on drainage outlets to tidal channels

TABLE 6.4(CONT)

Issues: SOLID WASTE MANAGEMENT	Approaches	Actions
<ul style="list-style-type: none"> ◆ Inadequate Urban Solid Waste Management 	<ul style="list-style-type: none"> ◆ Enforcement of contracts for garbage collection ◆ Introduce standardisation into refuse containers ◆ Better on-farm management 	<ul style="list-style-type: none"> ◆ Greater supervision of the operation of the garbage collection contractors with realistic tender award in relation to the true cost of contract execution. ◆ Public awareness campaigns to improve kerbside placement of waste (siting, containers, need for this form of disposal rather than other) ◆ Agreement on standard container design(s) for St Lucia
<ul style="list-style-type: none"> ◆ On farm solid waste management improvement 	<ul style="list-style-type: none"> ◆ Clearly identified landfill areas with effective management and control 	<ul style="list-style-type: none"> ◆ Use of trash for under banana erosion control (stabilisation of the trash). ◆ Reduction of debris wash from farm areas through drainage control measures, possible trash screens etc (see DRAINAGE).
<ul style="list-style-type: none"> ◆ Landfill site control 	<ul style="list-style-type: none"> ◆ Enforcement of contracts for garbage collection ◆ Reduction in indiscriminate dumping 	<ul style="list-style-type: none"> ◆ Public awareness campaigns ◆ Promotions by the Solid Waste Authority
<ul style="list-style-type: none"> ◆ Indiscriminate dumping of solid waste 	<ul style="list-style-type: none"> ◆ Introduce clear-up campaigns ◆ Introduce 'polluter cleans' concept 	<ul style="list-style-type: none"> ◆ Public awareness campaigns to reduce/eliminate indiscriminate dumping ◆ Enforcement of fines for illegal tipping/dumping (policing of identified illegal dump sites, particularly near to the drainage network) ◆ Emphasis on dump clearance in advance of the flood season.
<ul style="list-style-type: none"> ◆ Lack of Coastal/ Estuarine Waste Control/ Clean-up 	<ul style="list-style-type: none"> ◆ Reduce incidence of discharge to the drainage system by improved treatment facilities 	<ul style="list-style-type: none"> ◆ Arrange for schools to undertake clear-up campaigns as part of the environmental education process (various studies on waste type can be undertaken). ◆ Culprits of illegal dumping to be directed to clear up the dump site (riverine) and to undertake a supervised clean-up of the associated estuarine/ bay (beach).
<ul style="list-style-type: none"> ◆ Sanitary Waste/ Sewerage ingress into the natural drainage system 		<ul style="list-style-type: none"> ◆ Assess the extent of the problem in different areas <ul style="list-style-type: none"> ○ - location and effectiveness of pit latrines/ water closets ○ - location and effectiveness of septic tanks ○ - need for provision of latrines/septic tanks where not already provided ◆ Identify key spill areas from sewage collection points to the river system ◆ Identify improvements required to eliminate the pollution and implement

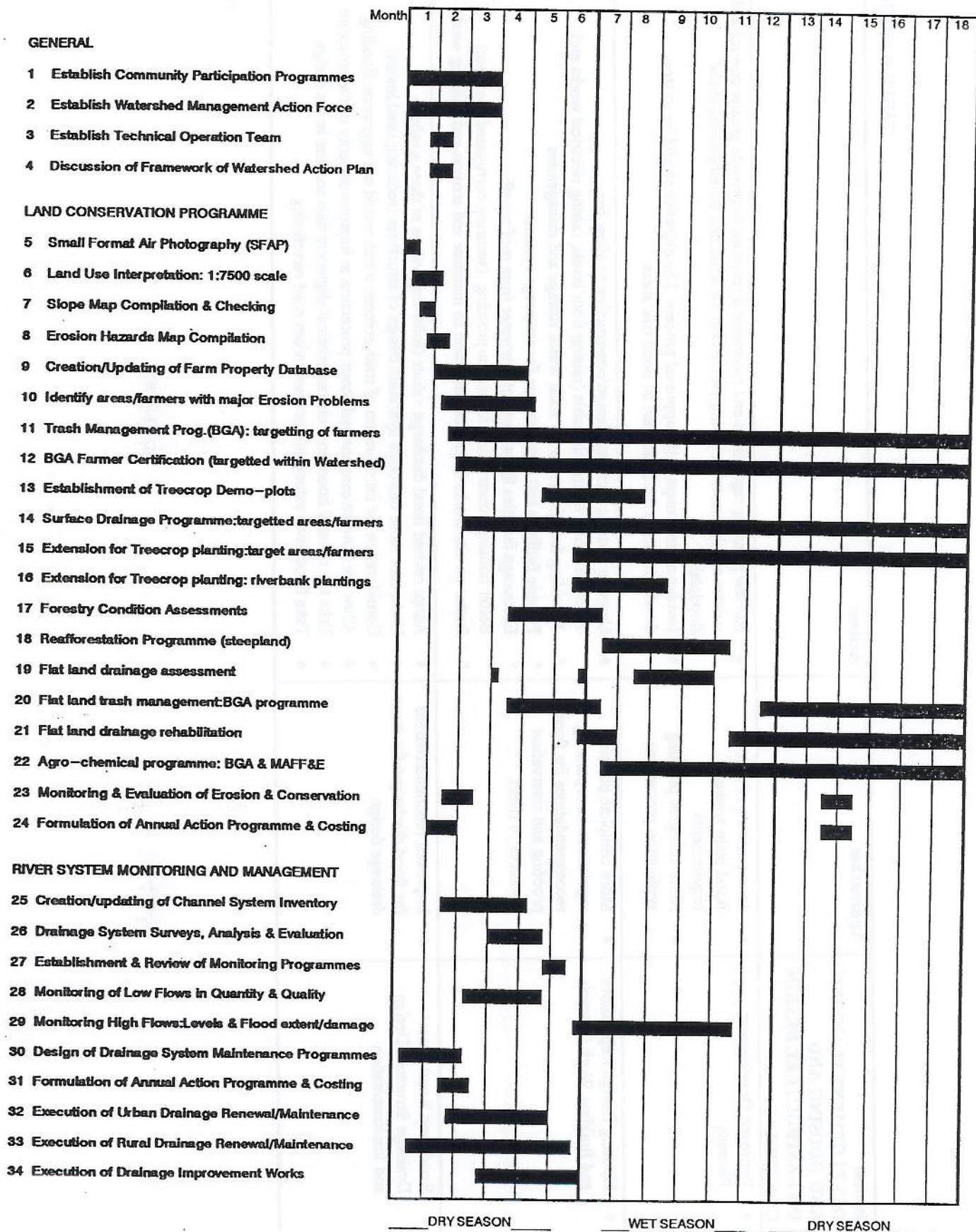
TABLE 6.4(CONT)

Issues: WATER RESOURCES UTILISATION	Approaches	Actions
<ul style="list-style-type: none"> ◆ Diminishing Baseflows in the River System 	<ul style="list-style-type: none"> ◆ Improved monitoring of river flows ◆ Undertake rainfall-runoff analyses to assess land-use impacts 	<ul style="list-style-type: none"> ◆ Introduce monitoring systems on key river systems and at all existing and proposed WASA intake sites ◆ Keep records of all flows and produce regular analyses for reporting to key government bodies ◆ Assess impact of low flows ◆ Undertake public campaigns to highlight problems of the upper catchments
<ul style="list-style-type: none"> ◆ Deteriorating water qualities of both baseflows and normal flows at Intakes 	<ul style="list-style-type: none"> ◆ Improved monitoring of river water qualities particularly near WASA intakes ◆ Assess extent of agriculture and human habitation within WASA intake catchments ◆ Assess overall water quality characteristics of the basin 	<ul style="list-style-type: none"> ◆ Provide greater importance to water quality monitoring with budget provision ◆ Monitor activity in the WASA catchment areas on an annual basis and control ◆ Monitor land use changes in the catchment as a whole and impose controls ◆ Inventory key farm drainage and other discharge points into the river system. Keep records of pollution incidents, both official and unofficial ◆ Provide advice on agro-chemical usage and trash management (see LAND CONSERVATION) ◆ Monitor and Control Effluent Discharges into the River System (see WASTE MANAGEMENT)
<ul style="list-style-type: none"> ◆ Intake and Delivery Pipeline Damage (by streamflows) 	<ul style="list-style-type: none"> ◆ Keep systematic records of problems and the solutions (and costs) applied ◆ Improved Intake siting and design ◆ More regular maintenance 	<ul style="list-style-type: none"> ◆ More co-operation between WASA and local 'action force' ◆ Carry out full systematic review of intake structures (with assistance of Consultants? ..already proposed?) ◆ Local assistance at clearing debris during flood season ◆ Local involvement in creating buffer zones near the intakes
<ul style="list-style-type: none"> ◆ Increasing Demand for Potable Water Supplies 	<ul style="list-style-type: none"> ◆ Check on system leakage ◆ Implement demand management ◆ Meet requirements 	<ul style="list-style-type: none"> ◆ Local awareness campaigns on the value of water and water conservation measures ◆ Local assistance to WASA in identifying system leakage ◆ Introduction of rainfall storage tanks both at domestic and communal level. Advice and technical assistance on the design and construction of such facilities
<ul style="list-style-type: none"> ◆ Nascent Demand for Irrigation Water Supplies 	<ul style="list-style-type: none"> ◆ Monitor irrigation usage ◆ Introduce licensing and charging system (annual) 	<ul style="list-style-type: none"> ◆ Local programmes on efficient irrigation techniques ◆ Awareness campaigns on the need for ecological flows in the river system ◆ Local monitoring of irrigation activities by the 'action force' groups
<ul style="list-style-type: none"> ◆ Water Rights, Water Pricing and Discharge Consents 	<ul style="list-style-type: none"> ◆ Implement legislation and modify if possible 	<ul style="list-style-type: none"> ◆ Awareness campaigns water rights and the value/ importance of water in the dry season ◆ Local monitoring of effluent discharge activities into the river system

TABLE 6.4(CONT)

Issues:	DEVELOPMENT PLANNING AND HOUSING AND INFRASTRUCTURE DESIGN CONTROL	Approaches	Actions
<ul style="list-style-type: none"> ◆ Improved Development Planning 	<ul style="list-style-type: none"> ◆ Incorporation of stricter flood plain zoning requirements ◆ More stringent planning application procedures 	<ul style="list-style-type: none"> ◆ Review planning regulations and recommend revisions to provide greater control and stricter requirements for giving permission for structural developments in the floodplain. ◆ Involve more groups in the approval process. The objective should be to stop developments in the floodplain or flood risk areas 	<ul style="list-style-type: none"> ◆ Upgrade housing /building design/construction to allow for: <ul style="list-style-type: none"> ○ Flood proofing where advisable (raising floor levels, raising electrical works etc) ○ Providing facilities/areas for solid waste storage and management ○ Provide facilities and requirements for sewerage systems ○ Encourage facilities for storage of rainwater from roof runoff ○ Better housing construction for storm-proofing (securing corrugated roofs etc) ○ Better on-site works during construction to minimise soil erosion and building waste
<ul style="list-style-type: none"> ◆ Housing Design Regulations and Building Work Controls 	<ul style="list-style-type: none"> ◆ More complete planning regulations incorporating recommendations for flood proofing and reservation distances to rivers 		<ul style="list-style-type: none"> ◆ Adopt revised flood discharge values (following values of these studies) ◆ Undertake more thorough hydraulic design of structures (reducing head losses) ◆ Consideration for introduction of trash screens which would not aggravate flooding ◆ Allow for downstream channel scour protection to improve integrity of the structure ◆ Take the channel flood flow characteristics/ alignment into account in the design ◆ Take flood level values into account when road resurfacing
<ul style="list-style-type: none"> ◆ Roads and Road Cross Drainage Structure Design and Implementation 	<ul style="list-style-type: none"> ◆ Improved recommendations for flood discharges for cross drainage design 		

TABLE 6.5: ACTIVITIES SCHEDULE FOR WATERSHED MANAGEMENT FOR A TYPICAL WATERSHED (BASED ON PILOT WATERSHED EXPERIENCE: ACTIVITIES TO BE CONCENTRATED IN 18-MONTH PERIOD)



DRY SEASON

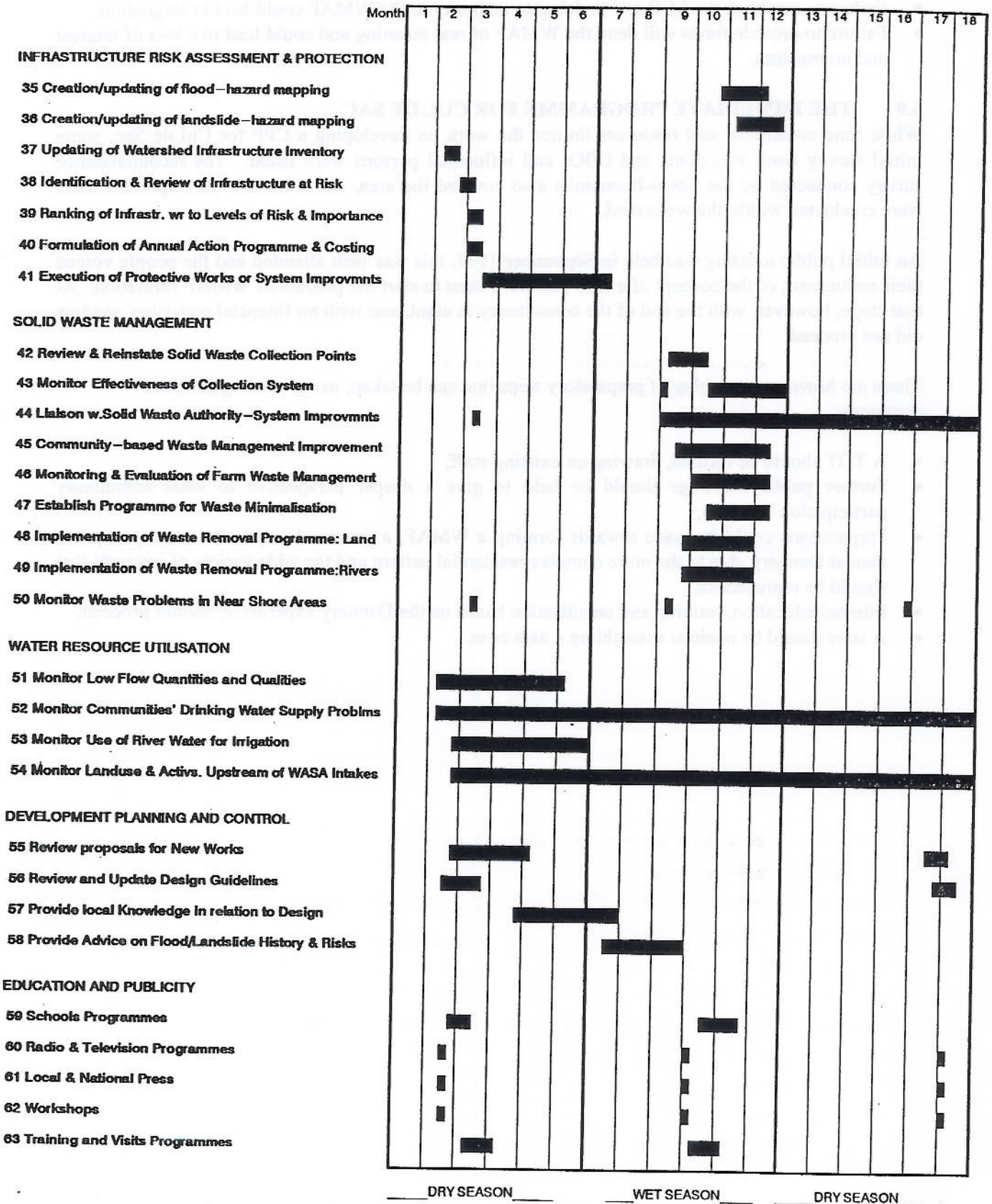
WET SEASON

DRY SEASON

Remarks: assumes initial programmes begin in early January. Many activities are season-specific.

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**TABLE 6.5 (CONT.): ACTIVITIES SCHEDULE FOR WATERSHED MANAGEMENT FOR A TYPICAL WATERSHED
(BASED ON PILOT WATERSHED EXPERIENCE: ACTIVITIES TO BE CONCENTRATED IN 18-MONTH PERIOD)**



Remarks: assumes initial programmes begin in early January. Many activities are season-specific.

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Some possible pitfalls are:

- Failure to establish the LCB and to delegate authority to the WMAF could lead to stagnation;
- Failure to provide funds will deny the WMAF of real meaning and could lead to a loss of interest and momentum.

6.9 THE IMMEDIATE PROGRAMME FOR CUL DE SAC

While time constraints and resources limited the work on developing a CPP for Cul de Sac, some initial survey work was done, and CBOs and influential persons were listed. The reconnaissance survey conducted by the Socio-Economist also covered the area, and a number of important trials were conducted within the watershed.

An initial public meeting was held in September 1997, this was well attended and the people voiced their enthusiasm of the concept of a CPP and were keen to start the process of WMAF formation. At that stage, however, with the end of the consultancy in sight, and with no financial provision, matters did not proceed.

There are however, a number of preparatory steps that can be taken, using existing staff and resources:

- A TOT should be formed, drawing on existing staff;
- Further public meetings should be held to give a deeper perspective to what community participation involves;
- Preparations could be made towards forming a WMAF, a process likely to be more protracted than at Dennery, due to the more complex residential pattern and the wide variety of interests that should be represented;
- Internal education, training and sensitisation based on the Dennery experience, should proceed;
- A start should be made at assembling a data base.

Chapter 7

7 DEVELOPMENT PROPOSALS FOR WATERSHED AND ENVIRONMENTAL MANAGEMENT

7.1 INTRODUCTION

This Chapter sets out the way in which the development priorities for the 37 watersheds was conceived and details the institutions for the management of the environment in general and of the watersheds in particular over the five year period 1998/1999 to 2002/2003. Preparing a development plan in a period of uncertainty and with few of the necessary structures in place, is a hazardous process and it would be prudent to revise the plan every year in the light of experience. A "rolling plan" should be prepared every November to coincide with the annual budgeting process and there is provision in Section 9.2.3 for an aid funded review in November 1999.

The development plan takes the view that the proper management of the Country's watersheds and of the associated river/coastal systems is the responsibility of GoSL and ultimately of everyone who lives on the Island. Non-governmental organisations, community groups, aid agencies and others can certainly help, but Government must put in place and operate the necessary management framework.

The solution to the problem, which everyone recognises, particularly after torrential or even heavy rain, requires a long term commitment, does not respond to a "quick fix" and requires a multi-agency approach. The Interim Report noted that:

"Integration of multiple agency interests into a single programme is difficult. Without exception, institutions will defend their turf and only yield authority and prerogative grudgingly. Getting institutions to co-operate in multi-sectoral activities towards integrated common goals - those that no institution can accomplish alone - is certainly one of the toughest jobs for natural resource authorities"

Whilst recognising the above, institutional strengthening, co-operation between agencies and decision making over the project period has been disappointing and Government's already minimal watershed management machinery is arguable weaker at the end of 1997 than it was at the start of the project.

7.2 PRIORITIES FOR WATERSHED DEVELOPMENT

During Phase 2 of the Watershed and Environmental Management Project, the watershed of Dennery and Cul de Sac were selected as pilot watershed for the development of Watershed and Environmental Management Plans. The two watershed were to provide a basis for the approach for the replication of the development of watershed and environmental management plans for the rest of the Island.

The Dennery Watershed was selected for being on the eastern windward coast with almost all its population located in a single urban centre (Dennery Town), which suffered considerably during TSD. By contrast the Cul de Sac Watershed, a major valley on the western (leeward) coast shows a high rural population located in ribbon developments along many of the roads, with agriculture (mainly bananas) being the main stay of the economy. Cul de Sac is now experiencing encroachment of activities from the Castries conurbation, including major industrial and commercial developments in the lower floodplain, a major road infrastructure project (all of which are causing major environmental problems), and residential areas rapidly expanding in Ciceron and in the area to the East of Morne Fortune. Cul de Sac again suffered major damage in TSD, with banana plantations ravaged by siltation and flooding. Both watersheds were relatively close to Castries which facilitated the studies.

The selection of the two pilot watersheds was made before the Consultants had sufficient time to fully evaluate the respective physical and environmental conditions of each of the watershed of the Island. The selection was made on the basis of initial data and information, the experience of the World Bank Appraisal Mission and the perceptions of numerous government staff.

The focus on the pilot watersheds has enabled the appreciation of what is really required at the watershed level. This has facilitated the consideration of what is required across all watersheds and has thus enabled the assessment to be made as to what institutional and government staffing support is required to support the local initiatives which are proposed.

The factors which have been taken into account in the selection process for the development of Watershed and Environmental Management Plans for the other watersheds of the Island include:

- intensity of agricultural development particularly overuse of banana land;
- population density;
- water resource availability;
- landslide vulnerability;
- importance and sensitivity of the coastal zone in the vicinity of the river mouths.

An approximate classification of the physical characteristics of each of the watersheds is presented in Table 7.1 whilst the land use details for each watershed is given in Table 7.2. The latter is based on the land use information in the Roche Itee study. The latter table also presents estimated values for the flood flows and dry season water resources of each catchment.

Based on the assessments presented in Chapter 4, a natural hazard risk assessment has been estimated for each of the main watersheds of the Island, and this is given in Figure 7.1. This risk assessment has been made for the upper, middle and lower reaches of each watershed related to susceptibility to land slides, flood damage and water resources deficiencies.

A systematic approach has been adopted for the analysis of the various factors listed above, but it is inevitable that there is a degree of subjectivity in the assignment of scores for each of the factors for each watershed.

The scoring related to each characteristic of each watershed is given in Table 7.3. A simple arithmetic addition of the marks is made to determine the aggregate for each watershed. This approach can be questioned; however, the process is only intended to determine an indicative order for the development of WEMPs and therefore their subsequent execution. It is the intention to cover all watershed with the programme.

Scores for 'Intensive Agriculture' were derived directly from the 'Estimated Percentage of Farmed Land' which was obtained from the Roche Itee (1993) study. Farmed land was included in four of the Roche Itee classes, but different reduction factors (from 0.5 to 0.9) were used to convert gross mapped areas to net farmed areas.

Scores for 'Population Pressure' were similarly initially obtained from the percentage of settlement areas (classes 11 and 12) in the Roche Itee mapping. However in comparison of these percentages with the settlement maps, large differences were seen in some watersheds and respective scores were adjusted upwards or downwards. These are noted at the foot of Table 7.3.

Other scores were based on the Consultant's knowledge of the different watersheds: in some cases there was an element of subjectivity in the assignment of the ratings (e.g. Roseau could be considered as top priority for irrigation development and would quickly run short of water).

TABLE 7.1 : ST LUCIA: PHYSICAL CHARACTERISTICS OF THE WATERSHEDS

No.	Watershed Name	Area (km ²)	Estimated Main River Length(km)	Estimated Catchment Length(km)	Average Catchment Width (km)	Catchment Maximum Altitude(ft)	Elevations (ft) 75% up Catchment	Main River Boulder %	Character Sand %	Other Rivers or Channels in the Catchment
1	Salle/Lapins	6.7	2.0	3.5	2.0	500	25	20	80	Lapins (20%)
2	Esperance	9.7	3.0	4.5	2.3	1000	150	20	80	
3	Trou Grauvail / Dauphin	10.0	1.5	4.5	1.0	900	150	30	70	Trou Grauvail // Petit Trou
4	Marquis	31.0	5.0	10.0	3.5	1800	200	30	70	Petite Anse // Souciere // Rav Chaloupe // +
5	Grande Anse / Louvet	29.2	2.0	4.0	-	2000	200	30	70	
6	Fond d'Or	41.0	7.0	14.0	3.0	1400	200	30	70	Rav Trou a l'Eau // Galet
7	Denney <<<<	21.4	5.0	8.5	3.0	1200	350	80	20	
8	Riviere Galet / Trois Islet	11.0	2.0	3.5	2.5	800	500	80	20	
9	Mamiku / Patience	16.0	3.0	6.5	-	1200	500	80	20	
10	Fond	18.1	7.0	10.5	1.5	1500	500	70	30	
11	Volet	8.6	3.0	4.5	1.2	1000	500	70	30	
12	Troumessee	31.7	10.0	15.0	3.0	3000	750	70	30	
13	Micoud / Ravine Bethel	13.1	4.0	7.0	1.5	900	500	70	30	
14	Canelles	17.3	7.0	12.5	1.5	2000	600	70	30	
15	Roarne/Rugeigne/Palmiste/St Urban	22.8	2.0	3.0	-	900	400	50	50	Ravine Concre River Ger
16	Vieux Fort	28.8	8.0	13.5	2.2	2000	1300	80	20	Rav Rugeine // Rav Palmiste
17	Black Bay	15.2	5.0	8.0	1.8	1000	500	90	10	Rav Languedoc // Rav Michel
18	Laborie	5.5	-	-	-	1000	900	90	10	
19	Playe	9.6	5.0	8.0	1.2	1300	900	90	10	
20	Balembouche	5.2	4.0	5.5	1.0	900	550	90	10	
21	Doree	11.1	8.0	10.0	1.1	2500	1000	90	10	
22	Choiseaul / Trou Barbet / Trou Marc	18.1	3.5	5.5	-	1600	1000	90	10	Trou Marc // Rav Valois // Trou Barbet
23	L'vrogne	6.5	2.5	5.5	1.2	2000	1000	90	10	
24	Pitons	7.1	-	-	-	2100	700	90	10	
25	Soufriere	17.2	4.0	6.0	4.0	1700	900	100	0	+ channels direct to sea
26	Mamin / Mahaut	13.7	2.0	4.0	-	1800	1000	100	0	
27	Canaries	14.6	5.0	9.0	1.5	1500	500	100	0	
28	Anses la Verdure / Cochon / Galet	13.1	2.5	5.0	-	1400	450	90	10	Anse Galet // Anse Cochon // +5
29	Grande Riviere de Anse-la-Raye	8.9	3.5	7.0	1.5	1200	500	90	10	
30	Petite Riviere de Anse-la-Raye	5.7	2.5	5.0	1.0	2500	400	90	10	
31	Roseau	49.1	9.0	17.0	3.5	1400	250	90	10	
32	Mt. Bellevue	4.8	-	-	-	1000	900	90	10	
33	Cul de Sac <<<<	40.9	10.0	14.0	3.0	1000	200	40	60	
34	Castries	14.3	2.0	3.0	2.5	700	100	80	20	
35	Choc	12.7	3.0	5.0	2.5	1100	200	70	30	
36	Bois d'Orange	11.3	5.0	7.0	1.5	200	200	50	50	Rav Fairview // Rav Castagne // +
37	Cap	15.4	-	-	-	-	-	-	-	

Note: values are approximate.

TABLE 7.2 ST LUCIA: WATERSHED CHARACTERISTICS

Land Use Category	PERCENT OF LAND USE CLASS IN EACH WATERSHED																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	Salee	Espernc	Dauphin	Marquis	Louvet	Fd.d'Or	Denery	Galet	Mamiku	Fond	Micoud	Trumase	Micoud	Cannels	Roarne	V.Fort	Bik	Bay	Laborie	Playe	Balmbuch
Natural Forest (1)	0.0	13.1	4.4	23.4	21.9	24.0	18.6	10.7	8.8	48.0	2.4	35.6	0.0	16.2	0.0	12.6	2.4	6.3	6.5	0.0	
Mangrove (2)	1.6	0.5	0.0	0.2	0.3	0.3	0.0	0.5	0.7	0.9	8.3	2.0	0.7	0.3	4.6	0.0	0.2	0.5	0.0	0.0	
Plantation Forest (3)	0.0	0.0	0.0	1.1	0.8	2.0	0.0	1.1	0.0	0.2	0.0	4.3	0.0	4.8	0.0	1.0	0.0	0.0	0.0	0.0	
Scrub Forest (4)	60.7	41.1	48.6	6.5	37.8	4.7	5.4	8.0	18.8	3.0	12.8	3.9	26.2	12.9	32.9	5.7	13.4	24.5	8.1	0.0	
Grass and Open Woodlands	13.4	0.0	6.9	0.0	1.5	0.2	2.3	0.8	3.3	0.0	0.6	0.3	11.3	2.9	9.6	5.1	9.0	8.0	0.0	0.0	
Mixed Farming (5)	14.0	21.5	14.7	19.2	21.9	24.3	47.4	24.4	21.6	19.1	26.6	13.6	14.0	21.7	13.9	26.6	35.5	41.5	36.0	15.3	
Intensive Farming (7)	0.9	16.0	22.6	40.2	11.2	30.5	21.1	51.7	34.3	20.8	24.9	36.7	35.0	34.3	15.6	39.3	24.6	8.4	41.8	57.0	
Farming Densely Vegetated	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	4.6	5.6	21.1	2.2	1.6	0.0	0.0	1.6	2.4	2.4	3.1	25.7	
Flatland Intensive Farming (9)	0.0	1.0	0.0	2.4	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.6	0.0	0.0	0.0	0.0	
Eroded Agricultural Land (10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Rural Settlement (11)	3.1	6.5	1.5	6.7	0.0	4.4	0.0	0.8	7.2	1.0	0.0	1.1	10.8	6.8	0.2	2.3	3.7	0.0	4.3	2.0	
Urban settlement (12)	4.0	0.0	0.0	0.0	0.0	1.7	5.3	2.1	0.0	1.2	1.3	0.0	0.0	0.0	18.9	3.3	8.9	8.4	0.3	0.0	
Rock and Exposed Soils (13)	2.1	0.3	1.3	0.2	4.6	0.1	0.0	0.0	0.5	0.2	2.1	0.3	0.4	0.0	3.5	0.0	0.0	0.0	0.0	0.0	
Water (14)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
TOTAL (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Total Watershed Area (km2)	6.7	9.8	9.7	31.3	28.9	41.4	21.2	10.0	15.9	18.2	8.6	31.5	13.6	17.5	21.7	29.8	15.3	5.4	9.8	5.1	
Mean Annual Rainfall (mm)	1530	1700	1630	2170	1810	2400	2090	1760	1840	2490	1970	2870	1900	2490	1600	2220	1770	1620	2320	1950	
Estimated Dry Season Characteristics:																					
Base Flows (l/s) (Table A.1)				35		80	80					300		100		120	30			80	
Catchment area (ha)				756		3458						2749		1597		1832					
Estimated run - off (l/s/sq km)				4.63		2.31						10.9		6.26		6.55					
Runoff % of estimated 'reserve'				10.4		2.4						5.6		4.6		6.3					
Estimated Flood Season Characteristics:																					
Runoff Coefficient	0.6	0.6	0.6	0.65	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.65	0.6	0.6	0.6	0.6	
Av. Rainfall Intensity (mm/h)	35	35	35	40	45	50	55	45	45	55	45	60	45	45	35	40	35	35	40	35	
Estimated Qp (m3/s)	39	57	58	224	256	399	229	96	140	194	75	370	115	151	133	208	89	32	64	30	
Land Use Characteristics:																					
% High Forest cover (1+3)	0.0	13.1	4.4	24.4	22.7	26.0	18.6	11.8	8.8	48.2	2.4	39.9	0.0	21.1	0.0	13.6	2.4	6.3	6.5	0.0	
% Natural Vegetation (1+2+4)	62.4	54.7	52.9	30.1	60.1	29.0	24.0	19.1	28.3	51.9	23.6	41.5	26.9	29.4	37.5	18.3	16.0	31.3	14.5	0.0	
% Estimated farming	7.6	22.8	23.2	40.0	18.8	40.5	38.4	48.4	37.6	27.5	43.3	33.8	32.4	34.9	18.6	44.1	36.4	28.1	49.1	63.0	
% Settlement (11+12)	7.2	6.5	1.5	6.7	0.0	6.1	5.3	2.9	7.2	2.2	1.3	1.1	10.8	6.8	19.1	5.6	12.6	8.4	4.6	2.0	
% Estimated farming land based on 90% of (9) + 70% of (7) + 60% of (8) + 50% of (6)																					
Assumed base rainfall (mm):1500; assumed months yield: 3. Source of Land Use data: HTS/MMI calculations based on Roche Itee (1993) data.																					

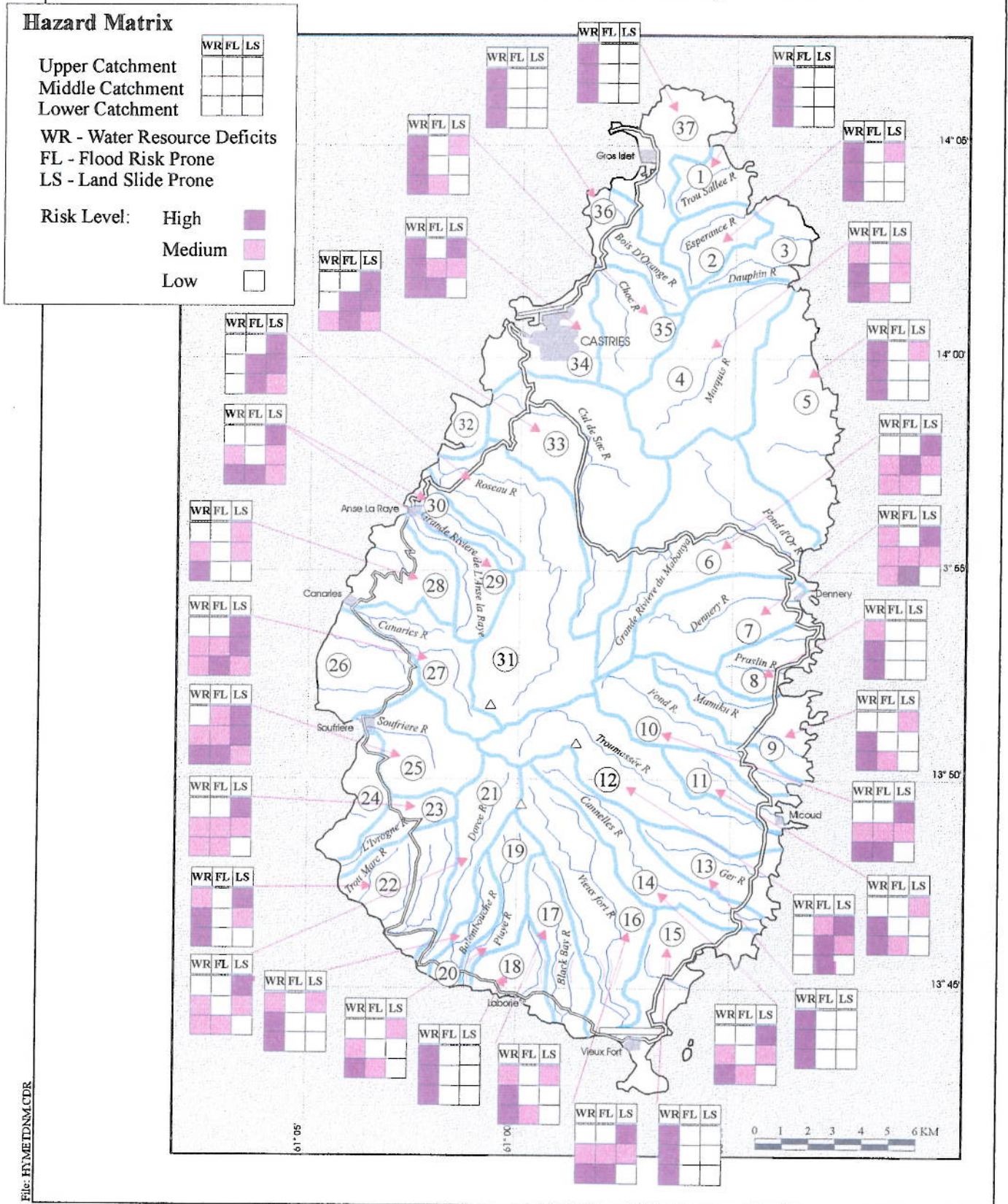
TABLE 7.2 (Continued) ST LUCIA: WATERSHED CHARACTERISTICS

Land Use Category	PERCENT OF LAND USE CLASS IN EACH WATERSHED																	37	Area(Km2)	%	
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37				
Doree	11.3	0.0	5.6	26.7	17.0	28.7	48.7	41.7	51.4	37.1	41.1	13.4	14.8	1.5	12.0	19.0	2.4	120.8	19.6		
Naural Forest (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.1	0.7	0.1	0.0	0.0	0.2	0.2	3.5	0.6		
Mangrove (2)	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.4	0.0	0.2	0.0	0.0	4.8	0.8		
Plantation Forest (3)	0.0	2.0	5.6	15.5	0.0	24.0	2.0	20.9	0.5	7.5	0.5	35.3	0.2	7.5	10.1	15.9	41.4	75.1	12.2		
Scrub Forest (4)	0.0	0.0	0.0	1.4	1.9	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	2.1	0.0	3.0	6.8	13.0	2.1		
Grass and Open Woodlands	45.8	26.6	14.4	9.6	35.3	28.5	38.0	33.3	33.2	37.3	16.9	3.5	21.6	11.7	24.2	19.5	14.8	144.8	23.5		
Mixed Farming (6)	24.9	47.1	46.8	5.7	21.3	6.5	5.2	1.4	13.1	9.4	28.5	5.2	38.2	13.4	35.6	15.0	1.7	162.5	26.4		
Intensive Farming (7)	12.2	1.9	20.5	19.4	15.1	9.2	4.5	0.4	1.2	0.0	0.0	0.0	1.9	0.0	0.0	0.4	0.0	17.2	2.8		
Farming Densely Vegetated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	9.2	0.0	2.3	0.0	0.0	13.2	2.1		
Flatland Intensive Farming (9)	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Eroded Agricultural Land (10)	4.0	12.8	5.3	2.0	4.5	2.6	0.7	0.6	0.0	7.1	2.9	9.2	5.5	3.4	11.7	9.3	2.2	23.6	3.8		
Rural Settlement (11)	0.9	9.6	0.0	5.7	4.1	0.4	1.0	0.6	0.0	1.6	0.9	32.6	6.5	60.2	3.9	17.6	26.9	32.4	5.3		
Urban settlement (12)	0.0	0.0	1.6	14.1	0.7	0.2	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.0	0.0	0.0	1.4	4.4	0.7		
Rock and Exposed Soils (13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.0	0.2		
Water (14)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	616.6	100.0		
TOTAL (%)	11.5	18.1	6.6	7.2	17.5	13.4	14.7	13.1	9.0	5.7	49.6	4.0	40.9	14.1	12.9	11.4	15.3				
Total Watershd Area (km2)	2800	2250	2200	2400	2800	2050	2800	2200	2750	2250	3050	1900	2700	1900	1875	1800	1500	2240			
Mean Annual Rainfall (mm)	100	1067	70	180	180	180	180	180	50	150	160	2661	6.01	4.0	10	756	1.32	2.8			
Estimated Dry Season Characteristics:																					
Base Flows (l/s) (Table A.1)	0.65	0.6	0.65	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.65	0.6	0.6			
Catchment area (ha)	35	35	35	40	45	50	55	45	45	55	45	60	45	45	35	40	35	35			
Estimated run - off (l/s/sq km)	39	57	58	224	256	399	229	96	140	194	75	370	115	151	133	208	89	89			
Runoff % of estimated 'reserve'																					
Estimated Flood Season Characteristics:																					
Runoff Coefficient	12.2	0.0	5.6	26.7	17.0	28.7	48.7	41.7	51.4	37.1	41.4	13.4	16.1	1.5	12.2	19.0	2.4	2.4	125.6	20.4	
Av. Rainfall Intensity (mm/h)	11.3	2.0	11.1	42.1	17.0	52.7	50.7	62.9	52.5	44.6	41.7	49.4	15.0	9.1	22.1	35.1	44.0	44.0	199.4	32.3	
Estimated Qp (m3/s)	47.7	47.4	52.2	20.4	41.6	24.3	25.3	17.8	26.5	25.2	36.0	5.4	46.9	15.2	39.1	20.5	8.6	8.6	208.4	33.8	
% Settlement (11+12)	4.9	22.4	5.3	7.7	8.6	3.0	1.7	1.2	0.0	8.7	3.7	41.8	12.0	63.6	15.6	27.0	29.1	29.1	56.0	9.1	
% Estimated farming land based on 90% of (9) + 70% of (7) + 60% of (8) + 50% of (6)																					

Assumed base rainfall (mm):1500; assumed months yield: 3. Source of Land Use data: HTS/MMI calculations based on Roche Itee (1993) data.

Figure 7.1

Natural Hazard Assessment by Watershed



File: HYME TDNM.CDR

TABLE 7.3 : ST LUCIA: SELECTION OF ENVIRONMENTALLY CRITICAL WATERSHEDS (OVERALL WEIGHTING)

No.	Watershed Name	Area (km ²)	Estimated % Farmed Land(1)	Percentage Settlement (1)	Population Pressure(2)		Perceived Environmental Scores		Flood Risk	Landslide Risk	Coastal Importance	Total Score	Rank
					Intensive(3)	Agriculture	Water Deficiency	Flood Risk					
1	Salle/Lapins	6.7	7.6	7.2	1	1	3	0	0	0	3	8.1	35
2	Esperance	9.7	22.8	6.5	1	1	2	1	1	1	3	10.4	23
3	Trou Grauvail / Dauphin	10.0	23.2	1.5	0	2	2	1	1	1	3	8.4	34
4	Marquis	31.0	40.0	6.7	1.5	4	2	1.5	1.5	2	2	12.1	13 =
5	Grande Anse / Louvet	29.2	18.8	0.0	0	2	3	0	1	2	2	7.7	37
6	Fond d'Or	41.0	40.5	6.1	2	4	1	2	1.5	1	1	11.2	19
7	Dennery <<<<	21.4	38.4	5.3	1	3	0.5	2	2	1	1	10.1	25
8	Riviere Galet / Trois Islet	11.0	48.4	2.9	1	4	3	1	1	1	3	13.0	5
9	Mamiku / Patience	16.0	37.6	7.2	1	3	2	2	1	1	3	12.9	6 =
10	Fond	18.1	27.5	2.2	0	3	1	2	2	1	1	8.9	32
11	Volet	8.6	43.3	1.3	0	4	2	1	1	1	1	9.2	30 =
12	Troumassee	31.7	33.8	1.1	0	3	0	3	0.5	2	2	11.3	17 =
13	Micoud / Ravine Bethel	13.1	32.4	10.8	1.5	3	2	0.5	2	2	2	9.4	27 =
14	Canelles	17.3	34.9	6.8	1	3	0.5	2	2	2	2	11.0	20
15	Roaine/Rugeigne/Palmiste/St Urban	22.8	18.6	19.1	3	2	3	0	0	0	3	10.7	22
16	Vieux Fort	28.8	44.1	5.6	1	4	2	2	2	1	1	12.1	13 =
17	Black Bay	15.2	36.4	12.6	2	3	3	1	1	1	1	11.3	17 =
18	Laborie	5.5	28.1	8.4	2	3	3	0	0	2	2	9.2	30 =
19	Playe	9.6	49.1	4.6	1	4	2.5	1	0.5	3	3	12.4	12
20	Balembouche	5.2	63.0	2.0	0.5	5	3	0.5	0.5	3	3	12.5	11
21	Doree	11.1	47.7	4.9	1	4	2	1.5	2	2	2	12.8	9 =
22	Choiseaul / Trou Barbet / Trou Marc	18.1	47.4	22.4	3	4	2.5	0.5	0.5	2	2	12.8	9 =
23	L'Ivrogne	6.5	52.2	5.3	1	5	2	2	1.5	2	2	13.3	4
24	Pitons	7.1	20.4	7.7	1.5	2	2.5	2	2	3	3	12.9	6 =
25	Soufriere	17.2	41.6	8.6	2	4	1.5	3	2.5	3	3	15.5	3
26	Mamin / Mahaut	13.7	24.3	3.0	1	2	2.5	1	0.5	2	2	8.8	33
27	Canaries	14.6	25.3	1.7	0	2	1	3	3	2	2	11.6	15
28	Anses la Verdure / Cochon / Galet	13.1	17.8	1.2	0	2	2.5	1	1	3	3	9.4	27 =
29	Grande Riviere de Anse-la-Raye	8.9	26.5	0.0	0	2	1	2	2	2	2	9.4	27 =
30	Petite Riviere de Anse-la-Raye	5.7	25.2	8.7	1.5	2	1.5	1.5	1.5	2	2	10.3	24
31	Roseau	49.1	36.0	3.7	1.5	3	0	2	2.5	1.5	2	10.8	21
32	Mt. Bellevue	4.8	5.4	41.8	3	0	3	0	0.5	1	1	8.0	36
33	Cul de Sac <<<<	40.9	46.9	12.0	3	4	1.5	3	3	1.5	1	16.3	1
34	Castries	14.3	15.2	63.6	3	1	3	2	1.5	0.5	3	11.4	16
35	Choc	12.7	39.1	15.6	3	4	3	2	1	1	3	15.7	2
36	Bois d'Orange	11.3	20.5	27.0	3	2	3	1	1	3	3	12.9	6 =
37	Cap	15.4	8.6	29.1	3	1	3	0	0	3	3	9.8	26

Note: (1): Figures from Table 7.2, derived from Land Use data of Roche Itee, 1993. (2): % settlement/5; (3): % Farmed Land /11 - score 0 to 5. All other scores 0 to 3. Population ratings for Watersheds 15,22,32,34,36,37 adjusted down to fit max score of 3; Watersheds 13,17,24,30 also adjusted down because of clearly lower population; Watersheds 4,6,20,31,33 adjusted up because of higher population.

The ranking as presented in **Table 7.3** was used to determine the programme of future WEMPs which is presented in **Figure 7.2**. Some rationalisation has been applied between the table and the figure through a decision to group adjacent watersheds to make the execution process less complicated. The grouping of the watersheds should make the establishment of WMAFs easier and also in easing the logistical problems associated with the development of the WEMPs and their subsequent servicing by staff from the WMU and RMU.

7.3 MANAGEMENT ASSUMPTIONS

The development plan is based on the assumption that considerable institutional improvements will be forthcoming and the following sections set out the minimum steps which GoSL should put in place. Failure to address these issues will weaken or even invalidate the development plans and aid donors might reasonably require evidence of GoSL commitment prior to making funds available. St Lucia has, at least in many fields, an adequate number of capable, well trained, civil servants and there are sufficient examples of well motivated units and individuals to support the view that progress is possible.

7.4 NATIONAL ENVIRONMENTAL MANAGEMENT

Figure 7.3 shows an organisational structure which is based on existing legislation and Cabinet decisions, but which needs to be put in place without further delay. It does not require the invention of new organisations, or any great initial increase in staff or expenditure. Implementation of the work would, however require co-operation amongst the agencies involved and a determination to make progress. The following Sections discuss the components of the structure in more detail.

7.4.1 National Environmental Commission (NEC)

Immediate steps should be taken to appoint the members of the NEC and Cabinet should be invited to consider the appointment of a non-government Chair - someone known to have a strong commitment to preserving and enhancing the environment.

The Commission should meet every second month, in the first instance and the meeting schedule should be set out a year in advance. Initial tasks would be:

- endorse the National Environmental Action Plan (NEAP) and set work priorities;
- consider and if possible endorse the watershed management development plan.

Every financial year, the Commission should check and agree all Government funds allocated for the protection/enhancement of the environment, prior to the announcement of the budget. In addition it would be appropriate for the NEC to allocate and require agencies including the LCB to be accountable for the expenditure of such funds.

At this stage the Environmental Unit in MFPIS&PS (referred to in **Figure 7.3** as the Environmental Office) does not require enlargement, although its future role, as the Secretariat for the NEC, monitoring/evaluating programmes, co-ordinating environmental legislation and involvement in international treaty obligations will require additional staff.

7.4.2 Operations Group

The units making up the Operations Group (see **Figure 7.3**) are mainly considered in Section 7.5 and are fundamental to management of the watersheds. The exception is the Coastal Zone Management Unit and it would be proper for the NEC to ask MAFF&E (Fisheries Department) to prepare a position paper regarding long term CZM plans. As with watersheds, the coastal zone is a GoSL responsibility and requires a dedicated institution to protect and improve the resource; projects can certainly assist, but the management process must be driven and co-ordinated by Government.

FIGURE 7.2

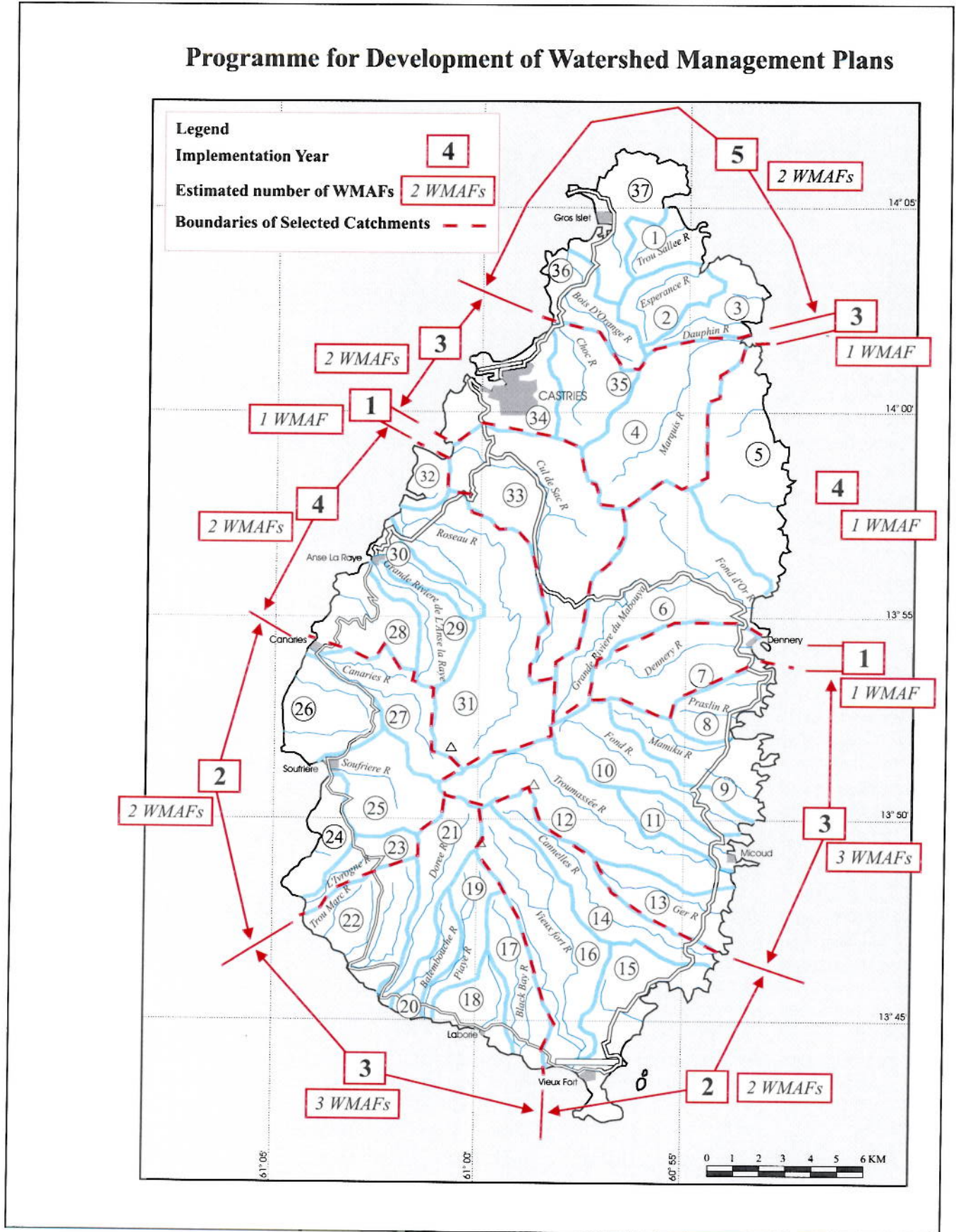


FIGURE 7.3

Proposed Structure for Environmental Management

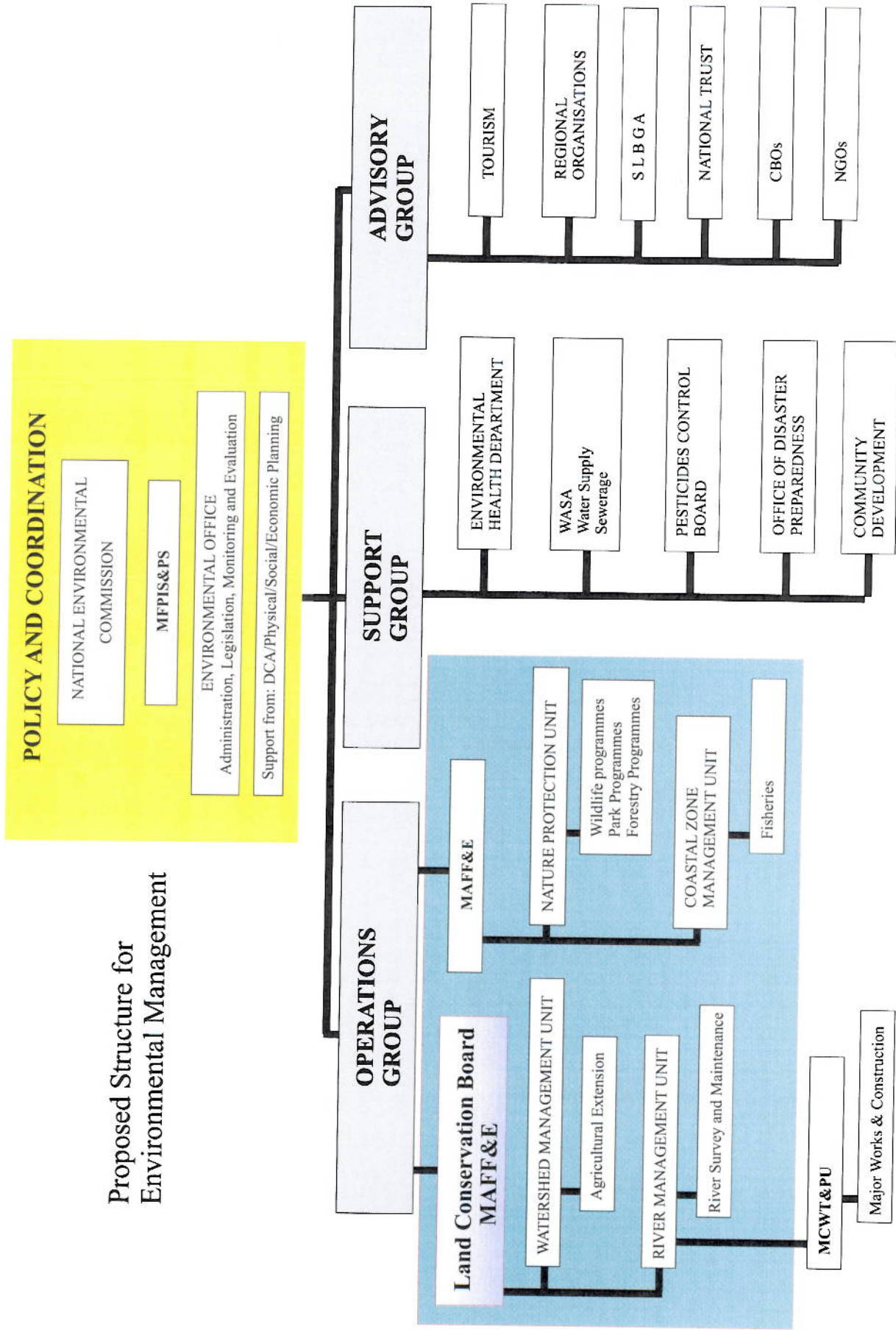
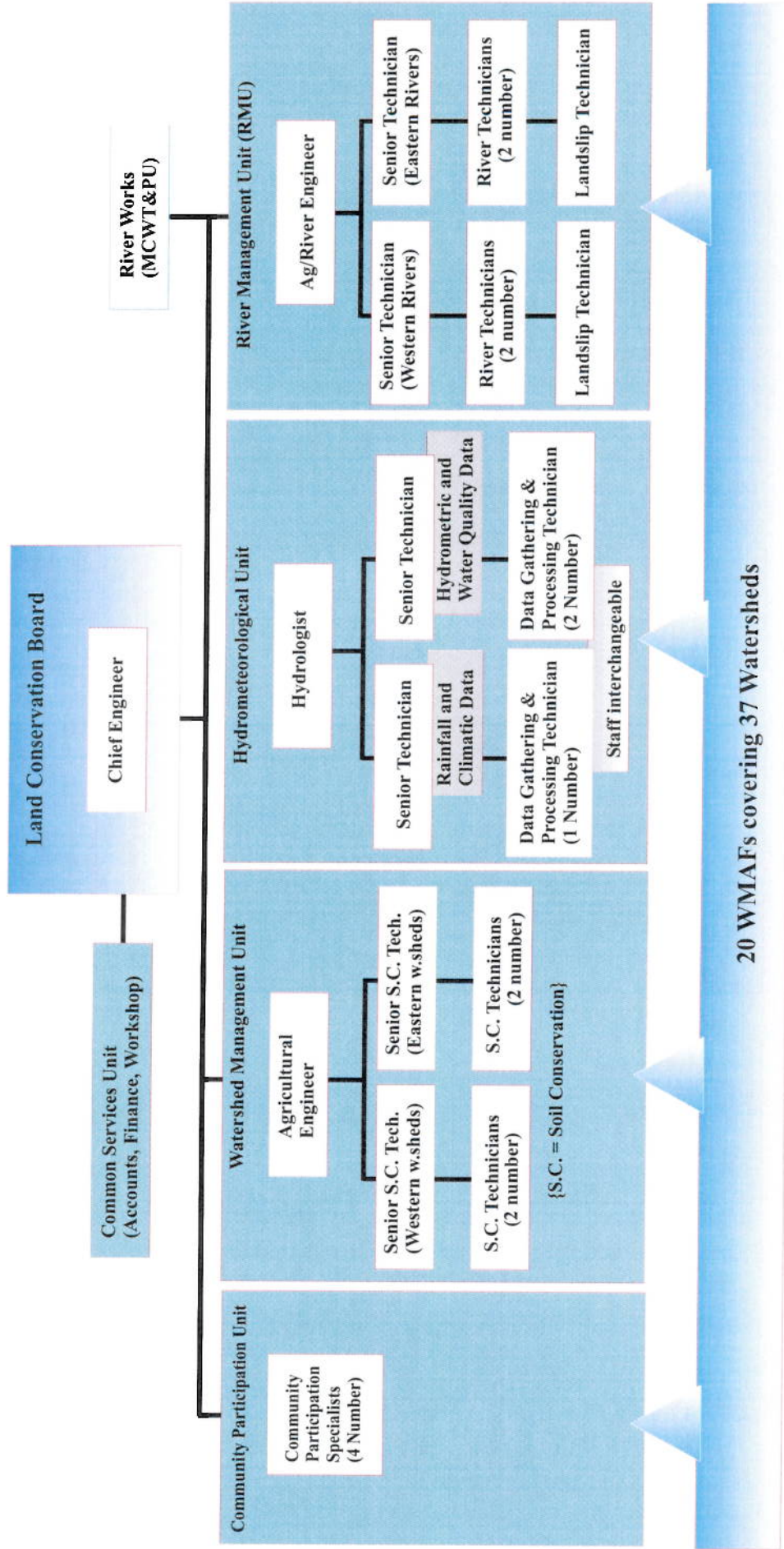


FIGURE 7.4

Watershed and Environmental Management



7.4.3 Support Group

The Support Group will have an indirect role in the watersheds and will include a number of government and quasi-government agencies, some of which are shown in **Figure 7.3**. These organisations will usually receive public funds and should be required to prepare annual environmental plans which relate to the NEAP and the watersheds. The plans would record progress against set objectives and the submission dates should be staggered throughout the year, to enable the NEC to give proper consideration to individual statements.

7.4.4 Advisory Group

The NEC should invite the organisations, which have wide environmental interests shown as the Advisory Group in **Figure 7.3** (not necessarily a comprehensive list) to an annual seminar to discuss important environmental issues. Papers for presentation should be available prior to the meeting and the NEC should encourage an active exchange of views. St Lucia has organisations with sectoral environmental interests (wildlife, archaeology, marine resources etc.), but appears to lack an active environmental pressure group. Far from discouraging a group of this nature, the NEC has an obligation to encourage healthy debate, particularly if it leads to action.

7.5 WATERSHED MANAGEMENT

7.5.1 Land Conservation Board (LCB)

Earlier Sections have made reference to the inactivity of the LCB and urgent steps must be taken to rectify the situation. An active Board supported by an efficient executive is essential to implementation of the development plan; **Figure 7.4** shows the organisation of the LCB and forms the basis for the development plan elaborated in this Section, with the costs detailed in Chapter 8.

The Land Conservation and Improvement Act makes provision for an 11 person board (7 government officials and 4 non-government members) and the Minister should consider:

- reducing the number of government members on the Board (e.g. the Secretary to the Board could be a non-voting member);
- appointing a representative from the tourist industry, the SLBGA and a banana grower to be non-government members of the Board;
- instructing that the Board meets every second month with meetings scheduled on alternate months to the NEC.

There is a need to draft Regulations for the LCB and later in the plan period (say 2000/2001) there may be advantages in changing the legislation to convert the Board into a more autonomous organisation, to be known as the Land Conservation Commission. There is provision in Section 9.2.2 for a legal specialist to address both of these issues.

7.5.2 Executive of the LSB

With effect from April 1998, the present AESD would cease to exist and all staff and resources would be transferred to the executive arm of the LCB. This change would recognise the need to:

- continue and improve the hydromet service;
- abandon any residual agricultural mechanisation ambitions;
- limit the provision of civil engineering services;
- concentrate on meeting the technical needs of soil/water conservation and development in the watersheds;
- develop a drainage and where appropriate, irrigation capability;
- meet the administrative and technical demands of the LCB and the WMAFs

The internal organisation of the LCB would involve five units as follows;

a) Common Services

This unit will supply the secretariat for the LCB, comprising the Chief Agricultural Engineer and Accounts, Secretarial and Workshop staff. It should be noted that the development plan assumes that the LCB will have greater financial responsibilities than the present AESD and there is accordingly provision to strengthen the LCB's financial capability.

b) Community Participation Unit

The number of Community Participation Programme Co-ordinators in this Unit would increase from 1 in year one to 4 later in the programme. There is provision in the development plan for WMAFs to incur recurrent and capital costs which would be controlled by the CPP Co-ordinators.

c) Hydromet Unit

The Hydromet Unit's duties, responsibilities and staff would differ little from the activities carried out by AESD at present. Staffing would consist of a Hydrologist and five technicians over most of the plan period.

d) Watershed Management Unit

At full development, the Unit would consist of an agricultural engineer and six technicians (3 to service the WMAFs in the west and 3 for the east of the Island).

e) River Management Unit

The River Management Unit would mirror the Watershed Management Unit and would also consist of an agricultural engineer and six technicians.

7.5.3 Watershed Management Action Force (WMAF)

The WMAF experience in Dennery is detailed in Annex 10 and there is sufficient information to estimate the staff and other costs required to promote WMAFs and the plan is based on the assumption that developments in all 37 watersheds will occur over the five year period. At year five this would involve the establishment of 20 WMAFs as listed in Table 7.4 and there is a strong possibility that:

- it will be impossible to achieve this level of development and/or;
- GoSL will require a different order of priorities for WMAF development

The Review Mission, scheduled for November 1999, will be in a good position to reschedule the development proposals, should this prove necessary in the light of experience. The priority for development has been predetermined in the case of Dennery and Cul de Sac, whilst in the other watersheds, development has been based on the perceived order of priorities discussed in Section 7.1.

The estimates in Chapter 8, make provision for LCB staff, both technical and the CPP Co-ordinators, but no financial provision has been made for the Technical Operations Team (TOT) staff provided by Extension, Forestry or other Government agencies required to implement the development programme in the watersheds.

7.6 NON-LCB STAFF INVOLVED IN WATERSHED MANAGEMENT

Previous mention has been made of the involvement of the Agricultural Extension Service in LCB work and there may be a need to formalise this relationship, for example by designating one officer in each region to work exclusively with the WMAFs. In addition, it is anticipated that the SLBGA (see Sections 9.4 and 9.6c) and the following units in the Forestry Department will be closely involved in the watershed development programme:

TABLE 7.4 DEVELOPMENT PROGRAMME BY YEARS

Year	Region	W/sh no.	Name	WMAF no.	Sq km
1	3	7	Dennery	1	21.4
	8	33	Cul de Sac	2	40.9
			Sub Total		62.3
2	5	14	Canelles	3	17.3
	5	15	Roarne / Rugeine / Palmiste / St. Urban	3	22.8
	5	16	Vieux Fort	4	28.8
	6	23	L'Ivrogne	5	6.5
	6	24	Pitons	5	7.1
	6	25	Soufriere	5	17.2
	6	26	Mamin / Mahout	6	13.7
	6	27	Canaries	6	14.6
			Sub Total		128.0
3	2	4	Maquis	7	31.0
	3	8	Riviere Gadet / Trois Islet	8	11.0
	4	9	Mamiku / Patience	8	16.0
	4	10	Fond	9	18.1
	4	11	Volet	9	8.6
	4	12	Troumassee	10	31.7
	4	13	Micoud / Ravine Bethel	10	13.1
	5	17	Black Bay	11	15.2
	5	18	Laborie	11	5.5
	5	19	Piaye	12	9.6
	5	20	Balembouche	12	5.2
	6	21	Doree	13	11.1
	6	22	Choiseul / Trou Barbet / Trou Marc	13	18.1
	8	34	Castries	14	14.3
	8	35	Choc	15	12.2
		Sub Total		220.7	
4	2	5	Grande Anse / Louvet	16	29.2
	3	6	Fond d'Or	16	41.0
	7	28	Anse la Verduce / Cochon / Galet	17	13.1
	7	29	Grande Riviere de Anse-la-Raye	17	8.9
	7	30	Petit Riviere de Anse-la-Raye	17	5.7
	7	31	Roseau	18	49.1
	7	32	Mt. Bellevue	18	4.8
		Sub Total		151.8	
5	1	1	Salle / Lapins	19	6.7
	1	2	Esperance	19	9.7
	1	3	Trou Grauval / Dauphin	19	10.0
	1	36	Bois d'Orange	20	11.3
	1	37	Cap	20	15.4
		Sub Total		53.1	

Total all Watersheds - 615.9 sq. km.

a) Protection and Patrol Unit and the Wildlife Protection Unit

During the plan period it is anticipated that there will be dialogue between LCB and the Forestry Department to determine areas of common interest in the watersheds.

b) Education and Information Unit

The CPP Co-ordination Unit in LCB should not establish its own information service, but rather come to an arrangement with the Forestry Department to use the services of the Education and Information Unit to provide publications and other material for use in watershed management campaigns

7.7 ADMINISTRATIVE REGIONS AND THE WATERSHEDS

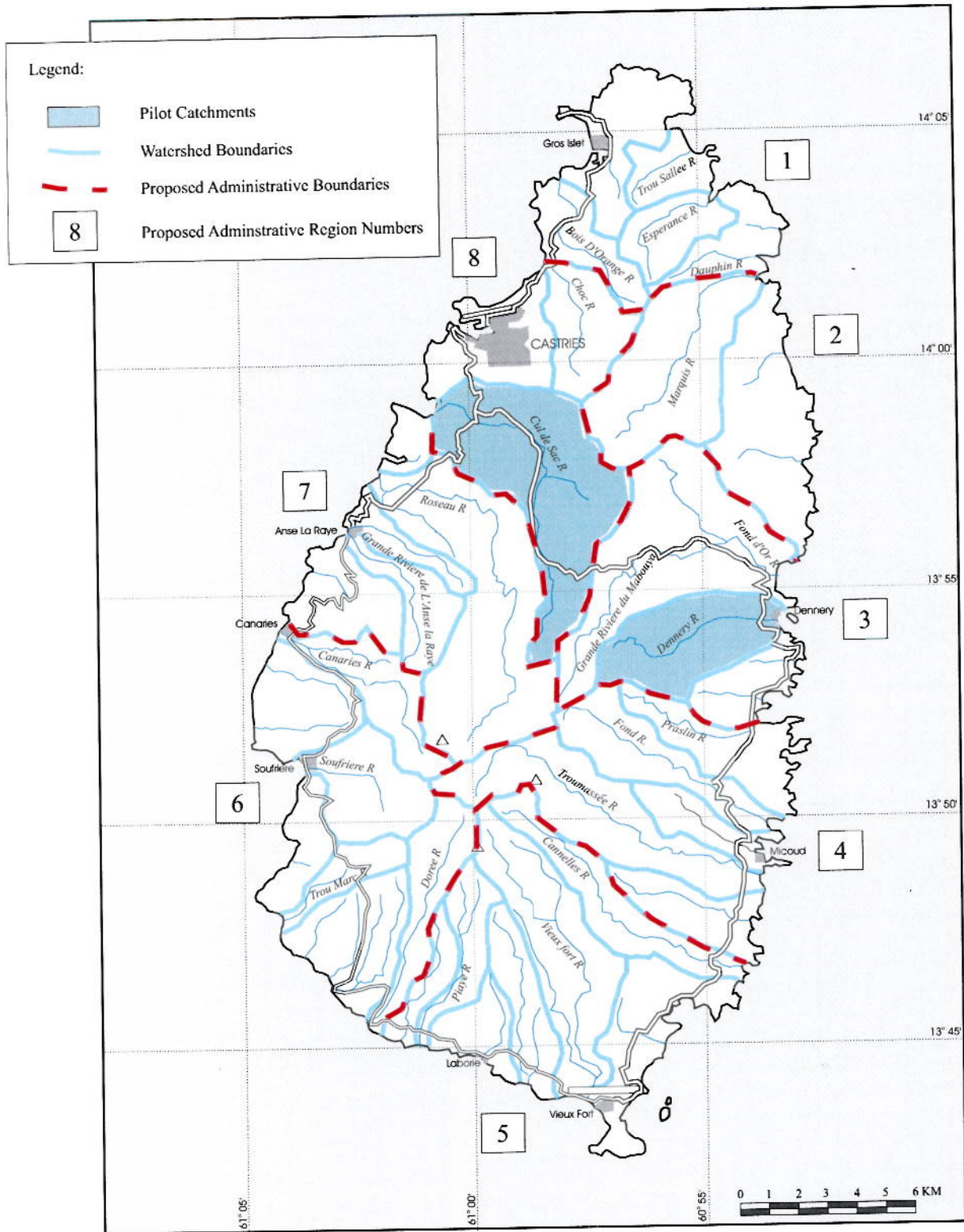
Administrative boundaries, in certain areas cut across watershed boundaries and this causes further complications in work programmes. The consultants experienced such a situation in their field trials work in the Cul de Sac Watershed, where half of the watershed was under the administration of the Bexon Agricultural Office (Region8) while the other part of the watershed was under the Roseau Office (Region7).

MAFF&E and preferably other Ministries should match the boundaries of the eight Administrative Regions to the thirty seven Watersheds in the Island, as shown in **Table 7.5** and **Figure 7.5**. In practice this would involve only minor changes in areas of responsibility and apart from being a logical development, the change would be a good opportunity for GoSL to demonstrate its commitment to watershed management. **Table 7.5**, shows that when re-configured the Regions are not all the same size (e.g. Region 5 is nearly twice the size of Region 1), but these differences are not important as staff should be deployed in response to need rather than simply land area.

TABLE 7.5 ADMINISTRATIVE REGIONS BASED ON WATERSHEDS

Region	Name and Number of Watershed	Total area (Sq km)
1	Salle / Lapins (1), Esperance (2), Trou Grauvail / Dauphin (3), Bois d'Orange (36), Cap (37).	53.1
2	Maquis (4), Grande Anse / Louvet (5).	60.2
3	Fond d'Or (6), Dennery (7), Riviere Gadet / Trois Islet (8).	73.4
4	Mamiku / Patience (9), Fond (10), Volet (11), Troumassee (12), Micoud / Ravine Bethel (13).	87.5
5	Canelles (14), Roarne/Rugeine/Palmiste/St. Urban (15), Vieux Fort (16), Black Bay (17), Laborie (18), Piaye (19), Balembouche (20)	104.4
6	Doree (21), Choiseul / Trou Barbet / Trou Marc (22), L'Ivroigne (23), Pitons (24), Soufriere (25), Mamin / Mahout (26), Canaries (27).	88.3
7	Anse la Verdure / Cochon / Galet (28), Grande Riviere de Anse-la-Raye (29), Petit Riviere de Anse-la-Raye (30), Roseau (31), Mt. Bellevue (32).	81.6
8	Cul de Sac (33), Castries (34), Choc (35),	67.4
	Total	615.9

Figure 7.5: ADMINISTRATIVE REGIONS RECONFIGURED TO WATERSHED BOUNDARIES



Chapter 8

8 COSTS OF THE DEVELOPMENT PLAN

8.1 GENERAL

This Chapter provides cost estimates for implementing the development plan at constant 1997 EC dollar prices over the five year period. It assumes that the plan will be reviewed / revised every November (when national budgets are prepared) for the subsequent five years, as part of a "rolling plan", in the expectation that the degree of precision will increase every year. Estimates have been divided into:

- recurrent costs to be met from the national budget for routine LCB expenditure;
- capital needed for remedial / improvement works in the watersheds; funds which might be made available from loan aid;
- income.

The development plan also assumes that the LCB will receive a significant amount of grant aid to support specific projects (see Chapter 9), including a donor financed mission to review progress in November 1999.

8.2 THE DEVELOPMENT OF THE BUDGET

The development of estimated maintenance costs and capital costs for small scale river engineering and landslide stabilisation works is presented in **Tables 8.1** and **8.3**. The costing exercise has been undertaken primarily to assess the Island wide implications of WEMPs of a nature similar to that proposed for Dennery and Cul de Sac. The values are by their nature approximate since the level of maintenance can be moderated as can the amount of river training works. More appropriate estimates will only be available after detailed river surveys are undertaken.

The estimation process undertaken for the Island wide costings is more approximate than undertaken for the Dennery and Cul de Sac plan development. In the former the combined estimated costs for Dennery and Cul de Sac is approximately EC\$ 250,000 whilst with the latter it is EC\$ 200,000. **Table 8.1** provides an indication of the possible inter annual variation which might be encountered in the maintenance programme. The estimates do not imply that effective river channel maintenance could not be obtained for less expenditure, a lower investment would purely imply less effectiveness. The same applies to the landslide rehabilitation and stabilisation aspects which are also covered by these costings.

It should be noted that these estimates in relation to urban drainage in particular and river engineering to some extent as well, need to be viewed in the context of normal annual government expenditure in these sectors. These being both maintenance programmes and capital works programmes. For example the Government Budget allocation for 1996/97 includes for the improvement in the Vieux Fort drainage works (EC\$14m), such works would cover costing included in the estimates given above. In the 1997/98 estimates, sums are included for the drainage of towns and villages under the budget heading 'Maintenance of Bridges and Culverts (and Drains)'. However these annual budgets are considered to be more than regular maintenance and more 'rehabilitation projects' in this sector.

Funds are often provided in post TSD situations to assist in post disaster rehabilitation. Funds were provided by the World Bank loan (EC\$ 17.4m) for the road and river network whilst the Caribbean Development Bank provided money for the reinstatement of the water supply system (EC\$ 15.4m). For the extreme costs indicated in **Table 8.1** such funding might still be forthcoming.

Table 8.1: Estimates of the Costs of River Engineering and Landslide Stabilisation/Recovery Works per Catchment

Watershed Name	Estimated Road Network Density			Landslide Propensity (approximate)			Devel- opment Factor		River Factor plus Enviro	Estimated Annual Surveys (days)		Estimated Costs of River Engineering Works		Slope Protection EC\$	Cross Drainage EC\$	Landslide Inputs Survey Time (days)	Survey Re-veg Cost EC\$	Estimated Maintenance Costs			Wet (1 in 5) 400% EC\$
	No. High	Med.	Low	High	Med	Low	V.Low	Factor		Factor (length)	Annual Surveys	Regular Maintenance	Dry (1 in 5) EC\$					Average 100% EC\$	30% EC\$	100% EC\$	
1 Sallee/ Lapins	0	2	2	✓	✓	✓	✓	30%	100%	24%	2.5	122	2,430	729	160	1.3	0	1,032	3,441	13,762	
2 Esperance	1	0	0	✓	✓	✓	✓	30%	100%	30%	3	198	4,500	1,350	80	1.9	2,425	2,566	8,553	34,212	
3 Trou Grauvai Dauphin	0	0	0	✓	✓	✓	✓	20%	100%	16%	3.75	97	1,215	365	0	2.0	2,500	1,253	4,177	16,707	
4 Marquis	5	1	1	✓	✓	✓	✓	100%	120%	203%	7.5	2,839	50,700	15,210	480	6.2	17,438	26,000	86,667	346,667	
5 Grande Anse Louvet	0	1	1	✓	✓	✓	✓	10%	250%	20%	3	113	2,025	608	80	5.8	7,300	3,038	10,126	40,504	
6 Fond D'Or // Mabouya	6	4	4	✓	✓	✓	✓	100%	200%	313%	10.5	109,375	32,813	32,813	800	8.2	23,063	51,653	172,175	688,700	
7 Denney	1	1	1	✓	✓	✓	✓	70%	100%	93%	6	1,128	23,144	6,943	160	4.3	21,400	16,833	52,776	211,105	
8 Riviere Gallet des Trois Islet	1	0	0	✓	✓	✓	✓	40%	120%	81%	2.5	408	8,112	2,434	80	2.2	2,750	4,134	13,781	55,125	
9 Fond	3	0	0	✓	✓	✓	✓	100%	100%	168%	5	1,521	25,350	7,605	240	3.2	4,000	11,615	38,716	154,864	
10 Mamiuku Patience	1	0	0	✓	✓	✓	✓	40%	100%	48%	7	745	16,940	5,082	80	3.6	18,100	12,284	40,947	163,789	
11 Violet	1	1	1	✓	✓	✓	✓	70%	100%	85%	3	559	12,705	3,812	80	1.7	2,150	5,792	19,306	77,222	
12 Troumasse	1	1	1	✓	✓	✓	✓	70%	100%	118%	10	2,603	59,150	17,745	160	6.3	71,325	45,295	150,983	603,930	
13 Micoud Riviere Bethel	1	0	0	✓	✓	✓	✓	100%	100%	181%	5	810	16,200	4,860	80	2.6	819	6,831	22,769	91,075	
14 Canelles	2	0	0	✓	✓	✓	✓	100%	100%	156%	10	2,781	54,688	16,406	160	3.5	17,300	27,401	91,335	365,340	
15 Rouarnes/ St Urbain	2	0	0	✓	✓	✓	✓	100%	130%	105%	2	463	10,530	3,159	160	4.6	0	4,294	14,312	57,249	
16 Vieux Fort	3	2	2	✓	✓	✓	✓	130%	130%	331%	9.5	6,426	132,496	39,749	400	5.8	28,800	62,361	207,871	831,483	
17 Black Bay	2	2	2	✓	✓	✓	✓	100%	130%	187%	5.5	2,172	46,800	14,040	320	3.0	3,800	20,139	67,132	288,526	
18 Labone	0	0	0	✓	✓	✓	✓	100%	100%	121%	0	0	0	0	0	1.1	0	0	0	0	
19 Playe	2	0	0	✓	✓	✓	✓	70%	100%	118%	5.5	1,372	29,575	8,873	160	1.9	600	12,174	40,560	162,319	
20 Bailembouche	1	0	0	✓	✓	✓	✓	100%	100%	196%	3.5	1,607	39,200	11,760	80	1.0	325	15,892	211,889	811,889	
21 Doree	1	1	1	✓	✓	✓	✓	70%	100%	128%	6	1,939	51,030	15,309	160	2.2	11,100	23,961	79,538	318,153	
22 Choiseul	4	1	1	✓	✓	✓	✓	150%	200%	397%	3.75	3,174	69,431	20,829	400	3.6	1,131	28,490	94,966	379,864	
23 L'ivrogne	0	0	0	✓	✓	✓	✓	100%	100%	210%	4.25	1,598	28,281	7,864	0	1.3	3,656	11,928	39,420	157,679	
24 Pitons	0	0	0	✓	✓	✓	✓	40%	100%	68%	0	0	0	0	0	1.4	7,100	2,130	7,100	28,400	
25 Soufriere	5	2	2	✓	✓	✓	✓	100%	100%	272%	4	2,398	54,450	16,335	560	3.4	26,875	30,185	100,616	402,463	
26 Mamin/ Mahaut	0	0	0	✓	✓	✓	✓	40%	150%	60%	3	336	6,000	1,800	0	2.7	856	2,698	8,992	35,969	
27 Canaries	1	1	1	✓	✓	✓	✓	70%	120%	165%	6.5	2,107	41,160	12,348	160	2.9	32,850	26,588	88,625	354,502	
28 Anses la Verdure	4	1	1	✓	✓	✓	✓	50%	100%	66%	3.75	463	8,266	2,480	320	2.6	3,275	4,441	14,803	59,213	
29 Grande Riviere de Anse-la-Ray	1	1	1	✓	✓	✓	✓	70%	100%	101%	5.25	988	17,640	5,292	160	1.8	8,900	9,694	32,980	131,919	
30 Petite Riviere de Anse-la-Ray	1	0	0	✓	✓	✓	✓	70%	100%	85%	3.75	593	10,588	3,176	80	1.1	3,206	5,293	17,643	70,572	
31 Roseau	3	2	2	✓	✓	✓	✓	100%	130%	157%	12.5	3,775	70,785	21,236	400	9.8	76,719	51,874	172,814	691,658	
32 Mt Bellevue	0	0	0	✓	✓	✓	✓	100%	100%	49%	0	0	0	0	0	1.0	300	90	300	1,200	
33 Cul de Sac	5	2	2	✓	✓	✓	✓	50%	130%	166%	9	3,461	83,200	24,960	560	6.2	92,025	61,262	204,206	816,824	
34 Castries	>8	many	many	✓	✓	✓	✓	200%	100%	288%	2	1,267	28,800	8,640	0	2.9	8,044	14,025	46,751	187,004	
35 Choc	2	1	1	✓	✓	✓	✓	150%	100%	384%	3.5	2,765	57,600	17,280	240	2.5	3,175	24,318	81,760	324,239	
36 Bois d'Orange	2	3	3	✓	✓	✓	✓	150%	100%	254%	4.5	2,636	63,375	19,013	400	2.3	2,825	26,475	88,249	352,956	
37 Cap	1	several	several	✓	✓	✓	✓	100%	100%	100%	0	0	0	0	0	3.1	0	24	80	320	
										175.5	59,587	1,233,740	370,122	7280	123.3	506,131	653,058	2,176,861	8,707,442	50 EC\$	

Notes: Estimated Survey Time for Landslides
 Estimated Survey Time per Main Channel
 Estimated Survey Time other channels
 Estimated Maintenance time per main channel
 Estimated Maintenance time per other channels
 Estimated Maintenance time per road bridge
 Estimated slope protection per km of main channel
 Estimated river training per km of main channel

The above are indicative build ups for assessing the national implications of the proposals being made in the context of Denney and Cul de Sac (Pilot Catchments)

Note:

53 28

These estimates assume an order of development as set out in **Table 8.7** which in turn was based upon the prioritisation exercise presented at **Table 7.3**. Should government wish to change the priorities, this will have implications on both recurrent and capital budgets, and reference to **Tables 8.1-8.3** will be necessary.

8.3 RECURRENT COSTS

8.3.1 Civil Servant Salaries

The establishment is based on the organisation set out in Section 7.4 and **Table 8.1**, indicates that staff salaries will increase from EC\$593,000 in 1998/99 to EC\$ 1,036,000 in 2002/3 and it should be noted that:

- there is provision to fill the vitally important Senior Co-ordinator, Agricultural Engineer (Rivers), Hydrologist and Accountant posts from year 1, although this may not be possible in every case;
- provision has been made to fill other vacant posts in line with the proposals for expanding the network of WMAFs over the plan period;
- it may be possible to fill the posts of Senior Technicians Eastern and Western Rivers and one of the Technician posts by transfers from MCWT&PU in 1998/99
- for the purpose of estimating, the following civil service salary grades (bottom of the scale) have been assumed:
 - Chief Engineer - Grade 17 (EC\$4,200/m)
 - Engineers, Hydrologist, Senior Co-ordinator - Grade 14 (EC\$3,550/m)
 - Accountant - Grade 12 (EC\$3,100/m)
 - Senior Technician and CPP Co-ordinators- Grade 9 (EC\$2,400/m)
 - Technician - Grade 7 (EC\$1,960)
 - Clerks - Grade 5 (EC\$1,500/m) or Grade 4 (EC\$1,300/m)
- provision has been made to increase civil servant salaries by 5 percent per year;

8.3.2 Daily Paid Staff

Table 8.4 shows an increase in daily paid staff from EC\$89,670 to EC\$97,970 over the plan period. No provision has been made for salary increases and it is possible that employee numbers will actually decrease by 2002/3, because some daily paid staff will be acting as technicians and thus re-graded or replaced in due course.

TABLE 8.4 STAFF COSTS OVER THE PLAN PERIOD - ECS

Civil Servants

Unit		Post	98/99	99/2000	2000/1	2001/2	2002/3
Common	IP (+)	Chief Engineer	50400	52900	55570	58350	61300
Services	Vac	Accountant	42500	44570	46790	49130	51890
	IP	Secretary	18000	18900	19850	20840	21890
	IP	Storekeeper	18000	18900	19850	20840	21890
CPP	Vac	Sen. Coordinator	42500	44570	46790	49130	51890
	IP	Secretary	18000	18900	19850	20840	21890
	Vac	Coordin 1		31500	33080	34800	36500
	Vac	Coordin 2			33080	34800	36500
	Vac	Coordin 3				34800	36500

Table 8.4 Continued

Unit		Post	98/99	99/2000	2000/1	2001/2	2002/3
Hydromet	Vac	Hydrologist	42500	44570	46790	49130	51890
	IP	Sen Technician (C)	30000	31500	33080	34800	36500
	IP	Sen Technician (H)	30000	31500	33080	34800	36500
	Vac	Technician 1		25200	26500	27800	29200
	Vac	Technician 2		25200	26500	27800	29200
	Vac	Technician 3			26500	27800	29200
W/s Mgt	IP	Ag. Engineer - W/s	42500	44570	46790	49130	51890
	IP	Sen Technician (W)	30000	31500	33080	34800	36500
	Vac	Sen Technician (E)	30000	31500	33080	34800	36500
	IP	Technician W1	24000	25200	26500	27800	29200
	Vac	Technician W2				27800	29200
	IP	Technician E1	24000	25200	26500	27800	29200
	Vac	Technician E2				27800	29200
River Mgt	Vac	Ag Engineer - Rivers	42500	44570	46790	49130	51890
	Vac	Sen Technician (RW)	30000	31500	33080	34800	36500
	Vac	Sen Technician (RE)	30000	31500	33080	34800	36500
	IP	Technician RW1	24000	25200	26500	27800	29200
	Vac	Technician RW2				27800	29200
	IP	Technician RE1	24000	25200	26500	27800	29200
	Vac	Technician RE2				27800	29200
			592,900	704,150	799,210	985,520	1,036,120

Notes

Staff list excludes one officer on suspension and another on a 2 year secondment to MVDP

(+) Officer on study leave in UK until September 1998, IP = In post, Vac = Vacant post as at November 1997

Daily Paid Employees							
	Vac	Mechanic	16640	16640	16640	16640	16640
	IP	Handyman	15230	15230	15230	15230	15230
	IP	Labourer - Hydromet	8300	8300	8300	8300	8300
	IP	Labourer W/s Mgt	11600	11600	11600	11600	11600
	Vac	Labourer E Rivers		8300	8300	8300	8300
	IP	Labourer W Rivers	8300	8300	8300	8300	8300
	Vac (*)	Labourer W Rivers	4200	4200	4200	4200	4200
	IP	Watchman	12700	12700	12700	12700	12700
	IP	Watchman	12700	12700	12700	12700	12700
			89,670	97,970	97,970	97,970	97,970

Notes

(*) Additional labourer for 6 months / year on the Delcer Canal

8.3.3 Travelling and Subsistence

a) Travelling

A Government scheme encourages civil servants, required to travel in the course of duty, to own vehicles by paying a basic allowance of EC\$500/month plus 92 cents/mile up to a maximum of \$300/month. Five staff members receive travelling allowances at present and provision has been made for all senior technicians and above to receive travelling allowances, as shown in Table 8.5

TABLE 8.5 TRAVELLING AND SUBSISTENCE ALLOWANCES

Year	No. Officers	Basic All (1)	Mileage (2)	Subsistence (3)	Total EC\$
1998/99	11	66,000	27,830	27,000	92,830
1999/00	12	72,000	30,360	32,400	102,360
2000/01	13	78,000	32,890	36,000	110,890
2001/02	13	78,000	32,890	45,000	110,890
2002/03	13	78,000	32,890	45,000	110,890

- Notes (1) \$500/m x 12 months,
 (2) 250 miles/m x 0.92 cents x 11 months/year
 (3) assumes 3 days/week 40 weeks/year. Staff increasing from 15 in year 1 to 25 in year 2

It is likely that travel allowances in year 1 and possibly in year 2 will be under spent.

b) Subsistence Allowances

Conditions of service, allow civil servants who spend more than 6 hours/day out of the office, to receive a subsistence allowance of \$15 per day. The plan assumes that the LCB staff will agree to payment of this, or a similar negotiated allowance, to cover work with the WMAFs at weekends and/or after normal working hours.

8.3.4 WMAF Expenses and Training Costs (Head 3025 - 08)

a) Training

Provision has been made for expenditure of EC3,000 in the first year of establishment of a WMAF to carry out internal training programmes

b) WMAF Expenses

There is provision for the LCB to meet some WMAF expenses and figures have been calculated on the basis of EC\$6,000/year for each WMAF (honorarium for the Secretary - \$1,500, community awareness campaigns - \$2,000, field expenses - \$1,500 and other committee costs - \$1,000). Ideally a Government subsidy of this nature should be phased out over time and the WMAFs encouraged to raise their own funds from drainage and conservation charges in the watersheds, however this is unlikely to occur during the plan period.

8.3.5 Other Recurrent Costs

The following Section is based on actual costs in 1997 and provides estimates for 1998/99, whilst Summary Table 8.6 allows for annual increases over the plan period.

a)	Office and General Expenses (Head 3025-09)	ECS/Year
i)	Books, Publications and Subscriptions	2,500
ii)	Protective Clothing (\$300 / employee / year)	<u>2,400</u>
		4,900
b)	Supplies and Materials (Head 3025-10)	
i)	Office Supplies	8,500
ii)	Cleaning materials and incidentals	<u>2,000</u>
		10,500
c)	Utilities (Head 3025 -13) and Rent (Head 3025-17)	
i)	Water, telephone, electricity	15,000
ii)	Rental (Delcer canal)	<u>250</u>
		15,250
d)	Tools and Instruments (3025-14)	
i)	Provides for the purchase of minor non-expendable and expendable items and because it is not necessary to replace items every year expenditure over the period should decline.	7,500
e)	Operation and Maintenance of Vehicles (Head 3025-16)	
i)	3 existing AESD vehicles	10,500
ii)	2 vehicles transferred from WEMP	<u>7,000</u>
		17,500

TABLE 8.6 SUMMARY OF RECURRENT EXPENDITURE OVER THE PLAN PERIOD (ECS)

Head	Code	98/99	99/2000	2000/1	2001/2	2002/3
Personal Emoluments	01	592900	704150	799211	985520	1036120
Wages	02	89670	97970	97970	97970	97970
Travelling	05	93830	102360	110890	110890	110890
Subsistence	05	27000	32400	36000	45000	45000
Training and WMAF	08	18000	48000	117000	117000	126000
Office and General	09	4900	5100	5400	5600	5900
Supplies / Materials	10	10500	11000	11600	12200	12800
Utilities	13	15000	15000	15000	15000	15000
Tools / Instruments	14	7500	7000	7000	7000	7000
O&M Services	16	17500	17500	17500	17500	17500
Rental of Property	17	250	250	250	250	250
		877,050	1,040,730	1,217,821	1,413,930	1,474,430

8.4 CAPITAL COSTS

The figures in Table 8.7 have been taken from the engineering estimates and are a first attempt to quantify the costs of maintenance and remedial works in the watersheds. It will be noted that there is provision for expenditure in the years when new WMAFs are scheduled to come on stream and there is some concern that the programme might, in practice, be overly ambitious. It should be noted that the estimates are additional to the recurrent costs for the LCB Units and these funds will be needed to pay for work carried out by force account or under contract, in the case of larger undertakings.

TABLE 8.7 CAPITAL COSTS (EC\$ '000)

W/sh no.	Name	1998/99	99/2000	2000/1	2001/2	2002/3
7	Dennery	53	53	53	53	53
33	Cul de Sac	204	204	204	204	204
14	Canelles		91	91	91	91
15	Roarne/Rugeine/Palmiste/St. U		14	14	14	14
16	Vieux Fort		208	208	208	208
23	L'Ivrogne		39	39	39	39
24	Pitons		7	7	7	7
25	Soufriere		101	101	101	101
26	Mamin / Mahout		9	9	9	9
27	Canaries		89	89	89	89
4	Maquis			87	87	87
8	Riviere Gadet / Trois Islet			14	14	14
9	Mamiku / Patience			39	39	39
10	Fond			41	41	41
11	Volet			19	19	19
12	Troumassee			151	151	151
13	Micoud / Ravine Bethel			23	23	23
17	Black Bay			67	67	67
18	Laborie			0	0	0
19	Piaye			41	41	41
20	Balembouche			53	53	53
21	Doree			80	80	80
22	Choiseul/Trou Barbet/Trou Marc			95	95	95
34	Castries			47	47	47
35	Choc			81	81	81
5	Grande Anse / Louvet				10	10
6	Fond d'Or				172	172
28	Anse la Verdure/Cochon/Galet				15	15
29	Grande Riviere de Anse-la-Raye				33	33
30	Petit Riviere de Anse-la-Raye				18	18
31	Roseau				173	173
32	Mt. Bellevue				1	1
1	Salle / Lapins					3
2	Esperance					9
3	Trou Grauvail / Dauphin					4
36	Bois d'Orange					88
37	Cap					1
	Total	257	815	1,653	2,075	2,180

The figure of EC\$2.18 million in year 5, is the anticipated expenditure in an “average year”, expenditure in a “wet year” might require in excess of EC\$8.7 million (and much more following another TSD) or as little as EC\$653,000 in a “dry year”. This variation in anticipated work load, underlines the need to engage labour when required and to avoid the danger of building up a permanent work force within LCB.

Although referred to as capital expenditure, this a generic term, used largely in the belief that GoSL might seek loan aid funds, routed through the LCB in order to undertake the programme. Funds would be used for:

- ongoing watershed management work (Watershed Management Unit)
- ongoing river management work (River Management Unit)
- other capital works

The ratio of the three types of work varies between the watersheds and Table 8.8 provides a first estimate of the breakdown of expenditure by years.

TABLE 8.8 BREAKDOWN OF CAPITAL EXPENDITURE (EC\$,000)

Expenditure	1998/99	1999/2000	2000/01	2001/02	2002/03
Watershed management	113	231	375	498	506
River management	37	152	332	412	437
Other capital works	107	432	946	1,165	1,237
Total	257	815	1,653	2,075	2,180

8.5 INCOME

At present there is no provision for the LCB and/or the WMAFs to raise drainage or land conservation rates (see Annex 11 Section 2.5.3) and this situation must change in the future. For example there is a need for on-farm drainage at Roseau, Cul de Sac, Fond d'Or, Troumassee and Canelles and thus the opportunity for the LCB to raise income through the imposition of a drainage rate in order to carry out the work by force account or contract. Whilst recognising that there will be opportunities to raise funds in the future, income flows over the plan period are unlikely.

Chapter 9

9 GRANT AID FOR THE LAND CONSERVATION BOARD

9.1 GENERAL

The development plan is based on the assumption that significant external assistance will be forthcoming over the plan period and this Chapter outlines the grant aid which might be available from one or more donors to support the LCB.

Where the capital items or recurrent costs involve local funds, the costs have been quoted in EC dollars, however where off-shore costs are involved, the projects have been defined in some detail, but costs have **not** been estimated on the assumption that this would be a matter for discussion between GoSL and potential donors.

9.2 TECHNICAL ASSISTANCE

Only one of the four professional posts in AESD is filled at present (the other officer being on study leave) and although the budget makes provision for appointments to LCB next year, it is probable that professional staff shortages will occur for some time. The following technical assistance appointments will provide the LCB with a degree of technical and managerial support during the formative years.

9.2.1 LCB Adviser

An adviser with experience in watershed management is required for 40 months over the first 4 years of the development plan to assist the Chief Engineer and to provide technical support to the Watershed and River Management Units. Additional duties would include:

- attending LCB and possibly NEC meetings in the role of a technical adviser;
- assisting with the preparation of budgets and future “rolling” development plans;
- assisting the Chief Engineer with the management of aid projects and the supervision of trials where necessary;
- supporting the Hydrometeorological Unit, particularly with the timely ordering and installation of equipment;
- ensure that remedial and other works identified by the CPP Co-ordinators and WMAFs in the watersheds are costed and built into forward programmes.

Provision has been made in LCB budgets for office support, vehicle running costs, internal travel and minor expenditure, but it is assumed that the adviser’s emoluments, accommodation, international travel and other allowances will constitute part of the aid package. Provision has been made in Section 9.3 b) for a vehicle.

9.2.2 Legal Specialist

A lawyer experienced in drafting environmental legislation is required for 4 months over 5 years (3-4 weeks/year) to review environmental legislation and draft changes where necessary. During the first input it would be necessary to review the tasks set out in Annex 11, decide on an order of priorities and agree a work programme. It is anticipated that a primary task would be to review the LCB Act, draw up regulations for the LCB and consider the legal status of the LCB and WMAFs

Legislative changes take time and political will, which means that inputs spread over time are likely to be more effective than a single visit. Annual inputs would allow time for the normal legislative process to take place, before initiating further changes.

Provision has been made in LCB budgets for office support, transport, internal travel and minor expenditure, but it is assumed that the legal specialist’s emoluments, accommodation, international travel and other allowances would be part of the aid package.

9.2.3 Review Mission

The development plan is based on a number of assumptions which may prove erroneous, or be in need of severe revision in the light of experience and a review of progress is proposed in November 1999. It is assumed that a donor will fund a two person team for one month to carry out this exercise.

Provision has been made in LCB budgets for office support, transport, internal travel and minor expenditure, but it is assumed that the review mission's emoluments, accommodation, international travel and other allowances would be part of the aid package.

9.3 CAPITAL

a) Improvement to LCB Offices

A sum, estimated at EC\$150,000, is required to improve the present AESD offices in order to service the needs of the LCB. Workshop space is surplus to requirements whilst office space is in-adequate even for the present staff. The development plan assumes that the LCB Adviser would be authorised to engage a local architect and to contract out the necessary work.

b) Vehicles

Following the end of the WMEP project, LCB will have 5 four wheel drive vehicles which, in addition to the use of private vehicles, should provide sufficient transport. However the vehicles are ageing and there is a need for one new vehicle (cost EC\$48,000 each) every year over the plan period.

c) Equipment

LCB will inherit the office equipment from the WMEP project and should thus be fairly well equipped in the short term. There is however, a need for office/field equipment to support the WMAFs and the approach would be for the CPP Co-ordinators to agree needs with individual groups in the year of formation. Provision has been made to supply each WMAF with a "once only" allocation of EC\$10,000 for the purchase of equipment and/or supplies.

9.4 SOIL CONSERVATION / TRASH MANAGEMENT AS PART OF SLBGA CRITERIA FOR FARMER CERTIFICATION

Improved soil conservation in steeply sloping banana land, notably by the maintenance of uniform trash cover and by installation of trash lines on the contour, will have a very favourable impact on reducing flash run-off and surface wash erosion. Less silt in the rivers and lower flood peaks would mean less damage during periods of high intensity rainfall and in addition less silt and rubbish being washed out to sea.

The recently established banana certification programme, which is currently checking 60 farms and certifying some 30 farms per week, is the mechanism most likely to achieve success in ensuring that farmers follow optimum trash management techniques for soil and water conservation. The current WIBDECO draft code of conduct for banana growers states that 5-isles bananas are environmentally friendly and general statements are made to this effect. There is now a need to be much more specific, and to ensure that farmers comply with soil conservation recommendations. If this is implemented, it would represent very good publicity for WIBDECO/SLBGA in the key premium markets in the UK: i.e. the bananas are environmentally friendly, both in use of chemicals (where existing policing in the certification programme is good), and in soil and water conservation, particularly on the steeper land farmed by poorer farmers (where much work still needs to be done).

Introducing soil conservation criteria and ensuring that farmers comply with the criteria will require additional manpower and LCB should make an annual grant to SLBGA to permit the Association to employ 5 field officers (one in each of the SLBGA advisory regions) over the 5 year period. These

extension advisers would be responsible for ensuring that certified banana growers carry out specific soil conservation measures as a pre-requisite for entry into, or for remaining in, the certification scheme.

The Soil Conservation Specialist (see Section 9.6.3 c) working with the LCB Adviser and Chief Engineer would be responsible for drawing up a detailed work programme and for drafting a contract with SBGA. The anticipated costs over a five year period would amount to EC\$140,000 in capital costs with recurrent costs of EC\$182,000 in year one, increasing to EC\$216,000 in year five, as detailed in Table 9.1.

TABLE 9.1 SLBGA PROJECT COSTS (EC\$ '000)

Expenditure	1998/99	1999/2000	2000/01	2001/02	2002/03
Capital - 5 vehicles (1)	140	--	--	--	--
Total	140	--	--	--	--
Salaries (2)	140	147	154	162	170
Subsistence Allowances (3)	10	10	10	10	10
Other SLBGA Overheads	17	17	17	17	17
O&M of Vehicles (4)	15	17	17	19	19
Total	182	191	198	208	216

Notes:

- (1) Small 4x4 vehicles at EC\$28,000 each
- (2) 5 extension officers at \$28,000/year increasing by 5 percent per year
- (3) \$2,000/officer/year
- (4) \$3,000/vehicle/year increasing

9.5 CROP DIVERSIFICATION

Misuse of steep land in the upper catchments where forest cover has been removed and land planted to bananas, has been diagnosed as a major cause of erosion in the uplands and flash flooding and siltation of river systems / drains in the valley bottoms. The solution is seen as a progressive change into permanent tree crops with potential for conservation and income generation in this steeper land. With current disturbance and restructuring of the banana industry a positive initiative is essential to obviate the risk of farmers, either abandoning land, or planting annual crops. Whilst this area of study falls largely outside the Consultant's ToR, and is peripheral to LCB's mandate, sufficient work has been done to indicate an outline programme.

In particular, earlier recommendations for a National Diversification Task Force, have met with strong support at senior levels and there is an urgent need for a 3 month consultancy to draw up a detailed work programme. At this stage it would be premature to judge the outcome of the study which could involve:

- possibility of establishing 1 acre demonstration plots in each WMAF area;
- each WMAF to set a target (say 10 percent of banana land over 25° slope in the first instance) for change to tree crops;
- deposition of funds to the National Credit Union Federation for on-lending to farmers prepared to plant tree crops at low rates of interest.

Provision has been made in LCB budgets for office support, transport, internal travel and minor expenditure, but it is assumed that the consultant's emoluments, accommodation, international travel and other allowances would be part of the aid package.

9.6 SPECIAL STUDIES

a) Low Flow Studies

Although the WEMP studies were originally conceived in response to TSD and the impact of the severe storm, one of the most critical issues to have emerged from the Phase II work is the high risk of water resource deficiencies in the dry season (December to May)

With increasing demands on dry season water resources by both domestic users and the increasing irrigation sector, it is vital that the limited resources are well managed. This requires reliable information on the base flows of the watersheds; information which is lacking at present.

An intensive 5 month monitoring programme is proposed, entailing streamflow measurements by current metering and allied water quality measurements. This would cover all watersheds although some catchments would have minimal or even zero flows. A team approach, utilising consultants and staff from AESD/LCB would require a foreign consultancy input of 10 staff months plus some minor items of capital expenditure.

b) Systematic Land Use Mapping (Small Format Aerial Photography)

Small Format Air Photography using a helicopter platform was obtained in Phase II and the detailed colour photography was extremely useful in giving an up-to-date assessment of land use. Similar photography is proposed for the other watersheds at approximately 1:6,000 scale to produce final land use maps at 1:7,500 scale. Maps would be digitised using PC Arc/Info software, facilitating overlaying with other coverages and analysis on the GIS.

The work would be split into two equal phases, each of 6 months duration: the first to start in month 2 and cover 50% of the watersheds, with the second input in month 37 to cover the balance of the watersheds. Some 17 staff months of Interpreter / GIS Specialists' time would be required, comprising some 5 months of time from a senior and 12 months from a junior specialist.

The cost of undertaking the photography would be EC\$ 64,000 including helicopter hire, films and processing, purchase of special camera, and construction of an apparatus to mount the cameras within the helicopter. Off-shore costs would be 17 staff months of specialists' time for the land use interpretation, ground-truthing, cartography, digitising, and GIS processing.

c) Effect of Trash Management on Run-off and Erosion over Micro-watersheds

Work done during Phase II showed that maintenance of trash cover had a marked beneficial effect on increasing soil infiltration rates with additional benefits such as protection of surface soil, anchoring of surface soil by banana roots, better rooting colonisation and nutrient recycling. However trials were not carried out for a sufficient time, or on a sufficient scale or under close enough supervision for any figures to be obtained on yield differences.

The effects of uniform trash management and trash lines on run-off and erosion should be quantified by monitoring 50-100 acre micro-watershed trials to assess the benefits obtained from optimum trash management compared with the current poor level of trash management. The base of each of the two micro-watersheds would have stream gauging installed to record run-off of both water and sediment; automatic rain recorders would also be installed at the sites. One site would have all of the farmers applying trash in the prescribed way whilst the other would act as a control with farmers applying trash as at present, with no uniform trash cover being maintained.

It is envisaged that a 3 month consultancy at the start of the project would be required, followed by 3 week inputs to monitor progress every 3 months in year 1 and every 6 months in subsequent years.

Work would be contracted out to WIBDECO / SLBGA who would provide local labour and technical supervision.

Project costs, excluding 11 months of foreign consultancy are detailed in Table 9.2.

TABLE 9.2 COSTS, MICRO-WATERSHED PROJECT (ECS '000)

Expenditure	1998/99	1999/2000	2000/01	2001/02	2002/03
Capital - 1 only vehicle	28	--	--	--	--
2 only automatic rainfall recorders	7	--	--	--	--
gauging / sedimentation tanks	10	--	--	--	--
Total	45	--	--	--	--
Salaries (1)	36	37	39	41	43
Subsistence / other allowances	2	2	2	2	2
Other SLBGA Overheads	5	5	5	5	5
O&M of Vehicles	3	4	4	4	4
Total	46	48	50	52	54

Notes (1) Technician at EC\$2,000/m and labourer at EC\$1,000/m increasing by 5 percent / year.

d) Bio-engineering and Landslide Warning Hazard

There is a minor requirement to monitor existing trials; this would amount to 10 weeks of local consultant time over the five year development plan period at a cost of EC\$8,000/ year

9.7 TRAINING

It is difficult to quantify training needs in detail and the plan assumes that an aid donor would build in provision for a certain amount of in-country or overseas short course training, at a cost equivalent to 10 percent of the cost of the foreign consultants. Table 9.3 shows a requirement for 87 staff months of consultancy inputs which translates into a training budget, equivalent to 9 months of consultant staff time.

9.8 SUMMARY

Table 9.3 summarises the LCB support proposals detailed in Sections 9.2 to 9.7 and indicates a requirement for EC\$787,000 in capital and EC\$1,371,000 in recurrent costs distributed over the plan period

In addition there is a requirement for 87 staff months of foreign consultancy and an unspecified requirement for short in-country, or overseas short course training at a cost equivalent to 9 months of consultant staff time.

TABLE 9.3 SUMMARY OF CAPITAL AND RECURRENT COSTS OF GRANT AID SUPPORT TO LCB (EC\$ '000)

Project	1998/99	99/2000	2000/01	2001/02	2002/03	Consultancy s/m
1. LCB Adviser	--	--	--	--	--	40
2. Legal Specialist	--	--	--	--	--	4
3. Review Mission	--	--	--	--	--	2
4a. Capital, Improve Offices	150	--	--	--	--	--
4b. Capital, Vehicles	48	48	48	48	48	--
4c. Capital, WMAF Equipment	20	40	90	30	20	--
5a. Capital SLBGA Project	140	--	--	--	--	--
5b. Recurrent SLBGA Project	182	191	198	208	216	--
6. Crop Diversification Study	--	--	--	--	--	3
7. Low Flow Study	12	--	--	--	--	10
8. Land Use Mapping	32	--	--	32	32	17
9a. Capital - Micro- w/s Study	45	--	--	--	--	--
9b Recurrent - Micro w/s Study	46	48	50	52	54	11
10. Landslide warning Hazard	8	8	8	8	8	--
11. Training (1)	n/c	n/c	n/c	n/c	n/c	9
Total	683	335	394	368	378	87 + 9 = 96

Note (1) Assumes a training cost, equivalent to 9 months of foreign consultant staff time.

Appendix A

Summary of Water Resources Conditions by Watershed

Summary of Water Resources Conditions by Watershed

Watershed 4: Marquis River (30.55 km²)

- high number of water abstraction points on the river system (26% of catchment) supplying Hill 20 treatment plant
 - intensive agriculture for decades;
 - water resources heavily utilised, little scope for further exploitation;
 - problems of turbidity and sanitary bacteriology at intakes;
 - Forestiere community located upstream of the main abstraction points (contamination risk);
- ⇒ needs improved treatment works;
- ⇒ needs better waste management from upstream habitations;
- ⇒ needs better agricultural practices (or less/ no agriculture upstream of the intakes).

Watershed 6: Fond D'Or/ Mabouya River (40.12 km²)

- 2nd largest river basin with 8% of area exploited for water supply;
 - catchment under intensive agriculture hence agro-chemical use is high, possibly impacting on resources;
 - water supply from the Thomazo stream is of poor quality although demand is small;
 - long proposed new intake site at Tournesse already of poor quality, although marginally better than the existing source;
 - other two intake sites, Ravine Cochon and Ravine Bassin Noire, both have good water quality, their catchments comprising >50% natural forest. Abstractions are very small and already dry season flows by 0.3 l/s and 6 l/s respectively.
 - serious water supply shortages exist at Derniere Riviere, Au Leon and the Mabouya Valley;
- ⇒ available water resources of the catchment are scarce, conservation measures should be adopted.

Watershed 7: Dennery (19.25 km²)

- single water intake fed by 10% of the whole river catchment. Supplies both Dennery and part of Mabouya Valley;
 - other parts of catchment have potential as supply area (Water Authority Forest Reserve) but shows evidence of agricultural encroachment;
 - water qualities in lower river reaches are often poor, affected by banana cultivation and possibly effluent from the garment factory;
 - turbidity problems from existing site dealt with by treatment works although effectiveness reportedly variable;
 - WASA have proposals to move the site further upstream thereby reducing the secure yield (new site still to be determined).
- ⇒ enforce >no agriculture= policy in catchment of existing intake;
- ⇒ investigate options for new intake in northern part of upper catchment to augment supplies to Mabouya Valley (adopt >no agriculture= in this WAFR);
- ⇒ review operation and performance of Dennery Treatment Works.

Watershed 12: Troumassee River (32.43 km²)

- one of the largest catchments in the Island with the highest estimated baseflows;
 - currently only has one small WASA intake (about 1.1 km² sub-catchment) and high risk delivery pipeline;
 - intensive agriculture in middle and lower valley (primarily bananas);
 - remoter areas around Quillesse also show declining water quality standards thought to be due to dasheen cultivation on steep terrain in the upper catchments (sometimes near forest reserve areas);
 - on normal storm path and badly affected by both TSD and the heavy rainfalls of October 26th 1996.
- ⇒ evaluate options for exploiting the water resources for the south of the Island;
- ⇒ ensure upper catchments are not encroached upon and that forest areas are maintained and possibly

- expanded to safeguard the relatively scarce water resource;
- ⇒ identify secure water delivery pipeline route and develop.

Watershed 16: Vieux Fort River (28.99 km²)

- severe problems of water quality exist and have affected WASA operations;
 - high turbidity loads in the middle and lower catchment, areas heavily cultivated;
 - new intake (4.1 km² catchment) and treatment works at Grace already considered to be at risk;
 - abstraction points have gradually moved upstream from 30m a.s.l, to 150m a.s.l. to the current level of 400m a.s.l.
 - small Saltibus intake (0.19 km²) currently has good if small abstraction capability but must constitute almost all of the available dry season resource at this site;
 - all water quality monitoring sites have shown quality declines during project period;
 - little of the catchment remains free from agriculture.
- ⇒ review agricultural coverage in the upper catchments.
- ⇒ identify means of reducing agricultural expansion into the upper catchment areas and of withdrawing agriculture from other areas.

Watershed 23: L'Ivrogne River (5.56 km²)

- about half of catchment feeds the intake which supplies the villages of Delcer and Choiseul;
 - (Choiseul catchment being one of the most severely eroded catchments in St Lucia);
 - water quality declining due to the growth of agriculture upstream of the intake;
 - intake suffers from sediment blockage during storms and supply treatment plant is affected by high turbidity levels;
 - high ammonia levels in the water indicative of residual volcanic activity in the area rather than human activity as in the lower parts of other more major catchments;
 - construction of new intake works just before the 1996 floods was affected by the accumulation of river gravel and stones upstream of the structure during the flood event in October.
- ⇒ intake catchment recommended to be requiring substantial conservation measures including grass and tree buffer zoning.
- ⇒ upstream monitoring of agricultural practices deemed advisable.

Watershed 25: Soufriere River (15.73 km²)

- WASA supplies based on a collection of springs, the resulting water has increased sulphate and sulphide content;
 - Ruby river also a source of water;
 - Soufriere River was severely disrupted by TSD and has been subsequently affected by the road construction work and the floods of October 1996;
 - biological habitat levels are low;
 - fast flowing water over large boulder bedded river yields high dissolved oxygen levels;
 - was a high risk main channel for Bilharzia.
- ⇒ agricultural activity is encroaching into the upper catchment areas and could modify the current fair quality rating of the Soufriere River; monitoring and control is required.

Watershed 27: Canaries (24.24 km²)

- upper catchment has relatively low level of agricultural activity;
 - area immediately around the intake site has banana and other tree crop cultivation;
 - fast flowing river during normal flows over boulder bedded river; high dissolved oxygen levels likely;
- ⇒ monitor any expansion in agriculture in the middle and upper catchment;
- ⇒ review intake pipeline alignment to the treatment works;
- ⇒ review operation of the treatment works;

Watershed 29: **Grande Riviere de l'Anse la Raye** (8.91 km²)

- small catchment with lower reaches having high level of agricultural activity;
 - surveillance programme indicated fair water quality throughout the period of study;
 - intake suffer from susceptibility to blockage;
 - plan to move the intake upstream is reportedly proposed by WASA (with reduced catchment ?);
- ⇒ review proposed move of intake, re-assess intake design to reduce susceptibility to blockage;
- ⇒ monitor agricultural encroachment into upper and middle catchments and the form of agricultural practices;

Watershed 31: **Roseau River** (48.08 km²)

- largest catchment on the Island and the only one with a major dam/reservoir facility (15.00 km² sub-catchment in the south east of the main catchment);
 - middle and lower catchments have an intensive agricultural system, dominated by banana cultivation;
 - middle and lower reaches of the river network have poor water quality ratings. The quality of the river flows at the Sarot intake (32.41 km²) being now very poor and the intake is no longer used;
 - water quality testing immediately downstream of the Roseau Dam have not indicated good quality water, however this is attributed to the fact that the impacts of the construction activity is still present;
 - testing on the Millet tributary of the Roseau River, downstream of the Millet WASA intake have given consistently good water quality results;
- ⇒ close monitoring of agricultural encroachment into the catchments of the Roseau Dam and the Millet intake needs to be undertaken;
- ⇒ continued monitoring of water qualities in the river system is advisable at these tow sites.

Watershed 33: **Cul de Sac** (38.8 km²)

- third largest catchment but only one water supply intake (4.44 km²);
 - middle and lower catchments have an intensive agricultural system, dominated by banana cultivation;
 - lower reaches of the Cul de Sac River has evidence of algal growth during the dry season;
 - abstractions are made from the lower reaches of the river for irrigation purposes;
 - middle reaches through Bexon are often contaminated by solid waste dumping;
 - lower and middle reaches of the river show low biotic scores indicative of poor water qualities;
 - at the intake site (Ravine Poisson), water qualities are variable and can be poor. This is attributed to the upstream agricultural activities. Qualities have been deteriorating;
 - river was a major risk area for bilharzia;
 - during flood events, the Cul de Sac River is a major conveyor of organic debris and solid waste material from the upper catchment, principally Bexon. Material is conveyed to the marine environment.
- ⇒ careful monitoring of water qualities at Ravine Poisson intake is recommended
- ⇒ monitoring of agriculture upstream of the intake should be undertaken with removal of such agriculture or tight control on practices (use of agro-chemicals; trash management for erosion control).
- ⇒ improved solid waste management programme in the catchment is essential.

Watershed 34: **Castries**

- has little agricultural production but is contaminated by organic debris and runoff containing solid waste material;
 - three sampling points were monitored although only one on a regular basis. The upper sampling point, sampled most regularly had a >fair water quality= although the taxa evidenced were considered to be pollutant tolerant.
- ⇒ considered to have no scope for water supply purposes.
- ⇒ improvement in solid waste and liquid waste management might improve the environmental quality of the flows in the river. Current water qualities of flows passing through the urban area of Castries is very poor and detracts from the towns character (impact on tourists?).

Watershed 35: Choc River (13.55 km²)

- ▶ medium sized catchment heavily developed and highly populated even in the upper catchment;
- ▶ some forest areas remain but agriculture is extensive;
- ▶ low base flows evident at Union although catchment still supports one WASA intake site;
- ▶ upper catchment monitoring point indicated good quality flows;
- ▶ river reaches near to the WASA intake showed contamination problems by waste materials. Reaches indicated algal formations on rocks and stones being attributed to the impact of human waste entering the drainage system;
- ▶ many taxa identified were considered to be pollutant tolerant;
- ▶ water qualities are reported to have become worse even over the last 2 years.
- ▶ better solid waste management needs to be undertaken;
- ▶ a review should be undertaken of the sewerage/ human waste management facilities and their effectiveness within the catchment. The impact of wastes discharges on low base flows which provide no dilution can be significant.
- ▶ abstraction of the very low baseflows for irrigation at the agricultural facilities at Union should be reviewed together with the impact of drainage returns containing agrochemicals and their impact on the marine environment nearby.

Appendix B

Summary of Flood Risk Conditions by Watershed

Summary of Flood Risk Conditions by Watershed

Watershed 6: Mabouya/ Fond d'Or

TSD

At the lower end of the catchment, the flood waters rose to the top of the handrailing at the Dennery Factory Site whilst further upstream at the Grande Riviere banana boxing plant, the building was flooded to a depth of 1.5m. Several communities were shallowly flooded, the community centre at La Resource was flooded but the school and church were not.

1996

Relatively low intensity rainfall is thought to have occurred in the catchment (the raingauge at Barre de L'Isle is not considered to be particularly reliable due to the proximity of high trees).

Various properties in the Grande Riviere area are liable to flooding, the banana boxing plant is particularly prone being flooded to a depth of 0.75m (note it was flooded to a depth of 1.5m during TSD). Although buildings at La Resource are not normally flooded, the road near the junction with the main Castries-Dennery road can be inundated to about 0.3m.

High soil losses are estimated to have taken place owing to the major remodelling works which was applied to the Mabouya River system during Phase 1 of the project.

Risk Assessment:

Although slightly to the north of the area where high intensity rainfalls normally occur, the catchment is large and hence high discharges can be generated. Any impediments to flow will therefore aggravate the flooding system. The works of channel resectioning and loop cutting carried out in Phase 1 should improve the conveyance ability of the channel in the lower reaches however, it may take some time for the river to morphologically stabilise and there could be bank slips for a few years.

Some dwellings near Grand Riviere have been at risk from flooding as was the banana packing plant. The minor road near Pelle which runs parallel to the Mabouya River (between Pelle and the Dennery Factory) has in the past been deeply flooded and signs should be placed at suitable locations indicating the risk. Dwellings and shops on the western side of La Resource have also been prone to flooding.

It is unsure as to what extent the Phase 1 works will reduce the risk of flooding in the valley. It will be useful to monitor the flooding experienced at the Grand Riviere banana boxing plant. However, the difficulty of the Mabouya/ Fond D'Or watershed is the derivation of a catchment rainfall depth and intensity measurement since the main rainfall gauges are outside the catchment. Comparison with 1996 may therefore be difficult especially without the flow records at the road bridge over the Grande Riviere du Mabouya.

Watershed 7: Dennery

TSD

Flood level reports indicate that flood levels in the town of Dennery were between 0.6m and 2m above the floor level of different buildings. Most buildings in the alluvial plain area to the north of the river channel were affected, particularly the church and community centre. Both the new Dennery school and the old primary school were flooded to a depth of 1m.

Upstream of the main road bridge, towards the Dennery Garment Factory significant flooding took place to depths of between 0.6m and 2.5m depending upon location. The former being immediately outside the Factory. The housing closer to the river will have been affected.

1996

Low intensity rainfall in the watershed and consequently low flood discharges caused little impact in 1996 and did not severely test the works built during Phase 1 to protect the town of Dennery.

Risk Assessment:

The catchment is prone to relatively high intensity rainfalls and is being further developed for agriculture. The catchment is relatively short and the channel is very confined until it reaches the east coast road bridge. The channel is susceptible to river bank landslides down as far as almost the garment factory. It is important to reduce the risk of channel blockages by good channel maintenance otherwise damage to the bridge could occur. The new flood protection embankment should protect the town of Dennery if completed to the correct bank top height.

Watershed 12: Troumassee

TSD

In the lower / middle reaches of the channel system, considerable damage was caused to banana plantations adjacent to the river. The track along the right bank of the river to the west of the main road was flooded in places to a depth of at least 1.5m. Flood depths in the river in the middle catchment zone was of the region of 6m. Normal depth from bed to bank top is about 2 to 3m.

1996

Trash marks indicated a high flood, flood levels being perhaps only 0.5m below that experienced during TSD. The inappropriate training works undertaken during Phase 1 at the main east coast road bridge which crosses the River Troumassee will have aggravated the flooding situation in the vicinity.

In the middle catchment, the Mahaut roadbridge was totally blocked with debris and the river broke through the left bank approach road. The blockage was the result of large river bank landslides which occurred upstream. The blockage would have destabilised the river, causing the erosion of the opposite bank and destroying a key track.

Risk Assessment:

The watershed is prone to high intensity rainfalls, whilst the catchment itself is large. Large flood flow volumes can thus be generated. Many sections of the channel are deeply incised and hence the risk of major river bank landslides into the main channel is high. Few if any dwellings have been identified in the active floodplain of the channel however, the main risk which is seen is from the blockage of the channel by river bank slides and/or the accumulation of debris at the bridge at Mahaut. Any channel blockage can hold back a significant volume of water which can break through forming a dam burst situation. The resulting flood wave will be attenuated as it passes downstream, but can still impose an additional >peak= on any flood flow to devastating effect. (It is in fact fortunate that the main road bridge was not severely damaged in 1996).

Watershed 14: Canelles

TSD

Flood marks are positioned some 1.7m above the track passing up the right bank of the valley from the main east coast road. At De Maily, this is about 3.3m above bed level.

1996

Relatively high intensity rainfall is believed to have occurred in the upper catchment. Flood levels were about 0.8m below TSD at De Maily. Banana losses were suffered in the lower alluvial plain areas. Such losses are likely to be a regular occurrence and not much could or should be done about it.

Risk Assessment:

The catchment of the river does not extend very far into the higher rainfall, central part of the island. The average width to length of the catchment is probably the lowest for any catchment on the island and hence it will be unlikely to have a high flood peak. The main rain belts move from east to west and hence in terms of catchment response will not yield as large a runoff per unit area as other catchments.

Watershed 16: Vieux Fort

TSD

Many areas were flooded to considerable depth.

Flood levels were 1.5m to 2m above the Coolie Town bridge deck;

- and 1.5m deep at the banana boxing plant downstream of the La Retraite Bridge (covering cars);
- and 1.5m deep at buildings at the Harlel Integrated farming Project;
- and 1m deep in the taxistand area of Hewanorra Airport;
- and 1m deep on the Vieux Fort cricket field,

whilst properties on the west of Vieux Fort, near the outfall of the old river, were flooded to a depth of about 2 m.

1996

Flood depths were generally less than TSD, however, not by much.

Flood levels were :

- and 1.0 m deep at the banana boxing plant downstream of the La Retraite Bridge (0.5 less than TSD);
- and 1.5 m deep at buildings at the Harlel Integrated farming Project (same as TSD, but the channel in this area was severely blocked);
- and 0.5 m deep in the taxistand area of Hewanorra Airport (0.5m less than TSD);

whilst properties on the west of Vieux Fort, near the outfall of the old river, were flooded to a depth of about 1 m (1m less than TSD).

Flood levels were given as being 2.5m above the deck of the La Retraite bridge, where one of the damaged hydrometric stations is located. The gauge would have been overtopped by such a flow and indicates a need for resiting with a longer stilling well.

Risk Assessment:

It is probable that the flooding in the area of Vieux Fort has been aggravated by both changes in the catchment through development (increased agricultural areas in particular) and also the re-alignment of the lower sections of the main channel to accommodate the airport.

The airport is considered to be at risk from flooding since the earthen embankments built, it is believed to protect the runway and other facilities, is incomplete and relatively poorly constructed. It is recommended that this situation should be studied at the earliest (it has already been brought to the attention of government staff).

Watershed 25: Soufriere

TSD

Although no flood marks remain from TSD various reported flood depths have been obtained. Flood depths of between 1m and 2m were reported on both sides of the main Soufriere channel downstream of the site of the bridge which was destroyed during the flood event on the eastern edge of the town. This bridge is currently being reconstructed with a new design. A school was reported to be flooded to a depth of 2m whilst several house on the right bank were badly damaged.

The main church was flooded to a depth of 0.6m whilst the deck of the main west coast roadbridge was flooded to a depth of 0.3m. This is very close to the sea and hence indicates the high discharge which passed down the river.

1996

Flooding occurred as a result of the under capacity footbridge across the river within the town area (Desmond Avenue to the school). This resulted in damage to property and the adjacent road which was being resurfaced at the time. The road outside the hospital was flooded to a depth of 0.5m.

Risk Assessment:

The upstream channel as it enters the municipality of Soufriere can be heavily laden with debris and also have a significant bed load (cobbles and boulders). This can make the entry point into the heavily populated zone at risk from movement. Attention should be given to upstream training works to ensure that the channel maintains its current route.

Considerable river training has been undertaken through the town area to the extent that the river is almost totally contained by either gabions or reinforced concrete walls. These training works performed well in 1996 during the passage of flood discharges probably as large as those experienced during TSD.

The conveyance of the water through the existing channel alignment is unfortunately constricted by the low support beam of the footbridge across to the main secondary school. This was identified as being the cause of the severe damage which occurred during the flood event of October 1996, however there appears to have been no move to have this structure removed or replaced. The structure puts at risk perhaps a dozen houses and road infrastructure and of course anyone using the footbridge.

The security of the WASA water supply intake needs to be checked.

Watershed 27: Canaries

TSD

Most of the town was subjected to shallow flooding. In addition properties on the road inland, Valley Road, were also affected and the road itself was shallowly (0.3m) flooded. The police station was flooded to a depth of 0.3m as was the school. Flooding at the junction of Cork Street and High Street was reportedly only 0.3m deep.

1996

Severe flooding took place and has in part been attributed to the reduced channel capacity brought about by the deposition of bed load material in the channel system upstream of the town during TSD.

Flooding at the junction of Cork Street and High Street was reportedly 1.5m deep although the depth of flooding near the police station was 0.75m. Thus the flooding in the town was probably at least 0.5m deeper than during TSD.

The failure of the new retaining wall just upstream of the west coast bridge on the left bank of the channel would have aggravated the flooding situation with gabion mattresses/ boxes being moved around in the channel and the fallen masonry wall forming a partial channel blockage.

Risk Assessment:

Although the main bridge has now been rehabilitated and an improved retaining wall arrangement provided upstream of the bridge, the channel capacity is still considered to be low since more bed material will have been deposited during the 1996 event due to the reduced downstream flow capacities.

More attention needs to be given to the training works through the town with checks being made of the conveyance capacity of the channel. {Based on a rainfall intensity of 70mm/hour, a run-off coefficient of 0.80, an estimated peak flow at Canaries would be of the order of $10 \text{ m}^3/\text{s}$ }. A distance of about 1km upstream of the main road bridge should be reviewed in terms of carrying capacity and river training works.

Attention should also be given to upstream channel blockages due to river bank landslips. This would be part of a regular river maintenance programme.

The WASA intake is in a relatively prone position, whilst the intake pipeline would not be immune to damage through river movement or river bed erosion. Protection measures are deemed advisable.

Watershed 29 and 30: Anse la Raye

TSD

The reports for flooding during TSD were basically equated with those for October 26th 1996. Since the latter is more memorable, it is summarised below and should also read for TSD.

1996

Flooding was reported to be similar to that experienced during TSD.

The flooding was severe with many dwellings being flooded to depths of between 1m and 2m. Of particular importance was the flooding of the Health Centre to a depth of 2m and the Community Centre to a depth of 1.5m, both of which should be critical in terms of disaster preparedness and response.

The main west coast road was flooded to a depth of 1m to 1.25m which caused disruption to traffic, another factor in relation to disaster response.

In the southern part of the town, the school playing field was reportedly flooded to a depth of 1m from the Grande Riviere although the church and surrounding area was not flooded.

Risk Assessment:

The town suffered equally severe flooding during both TSD and October 1996 with key buildings being flooded and rendered useless for a significant recovery period.

The town suffers from a critically inadequate drainage system particularly in the northern part of the town where the flood flows from the Petite Riviere de Anse La Raye passes under the main road and thereafter through/ between various buildings to the sea. The carrying capacity of this channel is inadequate whilst the cross drainage structure on the road and the downstream conveyance system is woefully poor. This is probably the cause of the flooding in the vicinity of the health Centre.

It is recommended that the drainage capacity in this area be upgraded to reduce the risk of flooding to the northern part of the town.

The carrying capacity of the Grande Riviere de Anse la Raye is better and the cross drainage structure of the west coast road is more substantial with a far greater flow area. The main concern for the condition of the Grande Riviere is the security of the WASA intake and the delivery pipeline to the water treatment works. Regular inspection and maintenance of the channel in this area should be undertaken.

Watershed 31: Roseau

TSD

Watershed would have behaved >unnaturally= owing to the debris entering the river flows as a result of the construction work on the Roseau Dam. Photographs of the debris stacked against the west coast road bridge are presented in the World Bank Mission Report of December 1994. Flood marks indicate that the west coast road would have been flooded to a depth of 0.8m.

Flows at the Vanard culvert/Irish bridge crossing were indicated as being about 1m above road level. At the bridge on the main west coast road, the water was indicated to be about 0.8m above road level, almost level with the bridge hand rail.

1996

Flood flows at the Vanard Crossing were only about 1.5m above the top of the culvert whilst the road at Morne D'Or was flooded to a depth of 0.3m.

The flood flows down the Millet River destroyed the left abutment of the Durandeu Bailey Bridge indicating high rainfalls in the upper Millet catchment. It is probable that high rainfall depths and intensities also occurred in the catchment of the Roseau Dam and that the dam itself provided some, or even considerable (dam was filling) protection downstream.

The flooding in the valley was much less severe than that associated with TSD although considerable areas of bananas were flattened in the flood plain of the river. This is considered to be primarily due to the impact of Roseau Dam, during TSD in aggravating the situation and during 1996 in attenuating the flood runoff. However, in addition, rainfall intensities in the catchment were probably lower in 1996.

Damage was incurred of the flood embankment works on the left bank of the Roseau River, just upstream of the Vanard Crossing. The embankments and protection gabions built to protect agricultural land was breached, damaging the bananas being protected.

Flood Risk Assessment:

Should be much reduced due to the operation of the Roseau Dam. Some attenuation of upper catchment flows will occur. Nevertheless, high discharges are still likely to be generated from the catchment during sever storm events. The operational characteristics of the dam are likely to be such that storm events may occur when the dam is full. It is reported that a large proportion of the storage capacity of the reservoir has been lost to sedimentation. {When this sum has been quantified, it might indicate what soil loss is occurring from other similar catchments.}

The bridge crossing at Vanard is unlikely to be damaged significantly although better downstream protection works should be undertaken. The main west coast bridge has survived two major floods and is thus considered to be >tested=, attention should be paid to the service facilities attached to the upstream face of the structure.

The security of the Millet Intake works needs to be monitored, both of the intake structure itself and the delivery pipeline.

The protection embankments to the agricultural land on the left bank of the river upstream of Vanard are likely to be attacked by the river and regular monitoring and protection will need to be carried out. This should be the responsibility of the farmer.

Watershed 33: Cul de Sac

TSD

Flooding in Bexon was indicated as being 0.7m above road level near the supermarket although the reports from the supermarket staff gave the level as being only about 0.3m above shop floor level (about the same above the road)

Trash marks at Ferrands Bridge (Texaco Station) gave a flood level 1.3 m above road level. This could have been caused by the blockage of Ferrands Bridge for a short period.

Flooding along the main west coast road was given as about 0.5m.

1996

At Ravine Poisson, the river remained in bank and the new retaining walls downstream on the left bank

remained intact. Flooding occurred over the road at Bexon to depths of below 1m and flooded the supermarket on the west of the main road to a depth of 0.3m (as per TSD?).

The bridge carrying the west coast road was overtopped and the main road towards the Hess terminal was flooded for a distance of over 500m and to a depth of about 0.5m. This is comparable to TSD but the measure is very approximate and any variation in flood discharge between the two events would be difficult to reflected in a flood depth over the road when the effective >weir width= (road length, is so long).

Flood Risk Assessment:

One of the larger catchments of the Island with an upper catchment prone to high rainfall intensities. Large floods were experienced both during TSD and during October 1996. Key areas at risk from damage are the various bridges across the river system and the properties in the lower lying areas of Ravine Poisson, Bexon and L'Abbaye.

Watershed 35: Choc

No flooding reports have been filed for the Choc River. However, flood flows were seen passing the bridge near the Forestry Department in both October and November 1996. The events were relatively similar with the crossing of the bridge being impossible for about 2 hours. Again this indicates the flashy nature of the flooding in almost all the catchments in St Lucia. It also highlights the spatial variability of the intense rainstorms since the November rainstorms only affected the north of the Island. In fact the November monthly rainfall as measured at Union Agricultural Research Station was almost an average value.

Appendix C

Watershed Management Workshop

Royal St. Lucian Hotel

27th July 1998

1 PROGRAMME

WATERSHED MANAGEMENT WORKSHOP

Royal St Lucian Hotel

27 July 1998

9.30	Introduction by Chairperson	
9.45	Opening Remarks	Hon. Prime Minister DFID in the Caribbean
10.00	Presentation of the main findings of the Watershed and Environmental Management Study	Hunting Technical Services
10.30	Open Discussion on the Study	
10.45	Coffee break	
11.00	Presentation of the Development Plan	Hunting Technical Services
11.30	Response	Government of St. Lucia
11.45	Response	World Bank
12.00	Response	DFID
12.15	Recommendations of the Meeting	Open Discussion
1.00	Lunch	

2 PARTICIPANTS

1	Hon. Dr. Kenny D Anthony	Prime Minister
2	Dr Peter Johnston	Stabex Funded Project (EU)
3	Mr Peter Haine	Stabex Funded Project (EU)
4	Mr Clairvair Squires	CDB
5	Ms Alison King-Joseph	Chairperson
6	Mr Samuel Wedderburn	World Bank
7	Mr Bishnu Tulsie	Ministry of Planning
8	Mr Lameck Kawicke	Ministry of Planning
9	Mr Michael Gittens	Ministry of Planning
10	Mr Embert Charles	NRMU (OECS)
11	Mr Raphael Eudovique	WASA
12	Mr Dick Beales	DFID in Caribbean
13	Mr Rod Matthews	DFID in Caribbean
14	Mr Peter Hughes	British HC, St. Lucia
15	Dr Vasantha Chase	NRMU (OECS)
16	Mr Felix Jaria	AESD, Ministry of Agriculture
17	Dr La Corbiniere	PS, Ministry of Planning and Finance
18	Hon. Cassius Elias	Minister of Agriculture
19	Mr David Louis	Ministry of Communications and Works
20	Mr Keith Nichols	NMRU (OECS)
21	Dr James Fletcher	PS, Ministry of Agriculture
22	Mr Aloysius Barthelemy	Ministry of Planning and Finance
23	Dr Julius Polius	Director of Agricultural Services
24	Mr Brian James	Chief Forest and Lands Officer
25	Hon. Calixte George	Minister of Communications and Works
26	Mr Cornelius Isaac	Ministry of Agriculture
27	Mr Lester Arnold	Ministry of Communications and Works
28	Mr Roosevelt Isaac	Hunting Technical Services
29	Mr Peter Humphreys	Hunting Technical Services
30	Mr Peter Thompson	Hunting Technical Services

3 PROCEEDINGS

3.1 Chairperson formally opened the meeting

3.2 Hon. Dr Kenny D Anthony, Prime Minister and Minister for Finance, Planning & Development, Housing, Information Services and the Public Service addressed the meeting as follows:

“Madam Chairperson, Mr Peter Hughes Acting High Commissioner, Messrs Dick Beales and Rod Matthews Representatives from DFID Caribbean, Mr Samuel Wedderburn Representative from the World Bank, Distinguished Guests, Ladies and Gentlemen

No one will deny that the sustainable growth and development of St. Lucia’s economy critically depends upon the preservation of our environment. Indeed, the continued growth of tourism, the leading sector of the economy, depends upon our ability to maintain the natural beauty of our island. The poor state of our watersheds also threatens the banana industry which continues to be an important sector especially for the rural areas. Government must therefore arrest the current rate of environmental degradation which we are currently experiencing

Adoption of the Action Plan

In this regard a National Environmental Action Plan (NEAP) was completed in 1997 and has been adopted by Government as the framework for environmental management and natural resource management. A National Environmental Commission will soon be appointed to implement the NEMP. In addition Government will re-vitalise the Land Conservation Board (LCB) which will provide technical support to the NEC.

The impetus for the renewal of interest in these broad institutional arrangements for environmental management emanated from this important Watershed and Environmental Management Study which we will be reviewing here today. The Plan was commissioned by the Government of St. Lucia and funded by DFID in the Caribbean in the wake of the environmental destruction caused by Tropical Storm Debbie (TSD). The establishment of a Watershed Management policy is of critical importance to Government in articulating a comprehensive integrated environmental framework which will guide Government’s concerted economic diversification drive in a direction that is sustainable.

As indicated earlier the impact of TSD served to highlight the scale of our environmental problems. While the damage caused by floods and storm are a major threat to our watersheds, the problems are much more fundamental being rooted in the ways our people have developed and exploited our natural resources in the past. It is imperative that we change these practices for the sake of our own survival.

Rehabilitating the Infrastructure

The objectives of the Project were to initiate the process of rehabilitating the hydraulic infrastructure of priority watersheds from the damage caused by the flooding and landslides arising from TSD. I take this opportunity to thank the World Bank for coming to the aid of the Government of St. Lucia by providing emergency assistance in our hour of need.

A reconstruction programme was successfully put in place and the Watershed project through the presentation, today of an Environmental Needs and Action Plan will be addressing the medium to long term requirements for sustainable watershed development, by adopting a more integrated approach to the development of our key watersheds.

Institutional Changes

For any project or plan to be successful, we have to look at the institutional arrangements which govern the process. The Watershed Project has as one of its main objectives, a review of the current institutional, legislative, regulatory and administrative environment, with a view to recommending appropriate changes that will enhance and support the Government's effort to manage its management.

This will take into account the need for the Government to strengthen capacities in environmental management and flood preparedness through the participation of local communities and the establishment of appropriate boards and organisations. This is essential if we are to foster an awareness amongst all St. Lucians of the harmful effects of environmental degradation and steps which have to be taken to reduce the impact of natural disasters on this beautiful island of ours.

In other words the Watershed and Environmental Management Project should allow the Government and people of St. Lucia to effectively manage our natural resource, strengthen and diversify agricultural production and foster development in the tourism sector, thereby ensuring the long-term sustainable development of St. Lucia.

Thanks to DFID

I wish to thank DFID Caribbean for its generous support to the Government of St Lucia over the years and in particular for making available technical assistance in the reconstruction phase of the watershed project and for engaging the services of Hunting Technical Services Ltd. To assist us in preparing the Environmental Action plan being presented this morning."

3.3

Mr Peter Hughes Acting British High Commissioner addressed the meeting drawing attention to the importance of environmental issues, the role of DFID in Caribbean and mentioning the British Government's White Paper on Development Partnership. Including the recent increase in overseas aid by £ 1 billion with clear guidelines established on aid policy

3.4

Peter Humphreys HTS Team Leader introduced the WEMP Draft Main Report emphasising the need to finalise the draft and move on to the implementation aspects of the plan

3.5 Main findings of the Draft Report

Peter Thompson HTS Legislation and Institutions Specialist presented the main findings by showing a series of 28 OHP transparencies

The following points were raised in discussion, with the Consultant's comments shown in *italics*:

- Mr Rod Matthews (DFID) asked why an economic analysis of costs and of the development (part of which would have to be carried by GoSL) and the benefits to be derived from the programme had not been carried out. *(ToR did not call for an assessment of the dis-benefits ie. cost of not carrying out the proposed programme, however if this is critical to future funding and development estimates could be prepared).*
- Mr Sam Wadderburn (World Bank) picked up on the same theme and whilst recognising that the ToR did not require such an analysis regarded this aspect of the study as a deficiency. He also commented that forestry as opposed to fruit trees had not been adequately explored and that the costs of both fruit trees and forestry were minimal. *(Provision in the development plan for a crop diversification study which would be an appropriate opportunity to address this issue)*

- Hon Calixte George made three points:
 - consultants have a snapshot of the problem, do not have the necessary data with which to work and the proposals may not be appropriate (*HTS started working on these problems in St. Lucia in the early 1980s - not exactly a snapshot*)
 - is environmental monitoring included in the plan? (*Yes*)
 - There are costs involved in instituting the plan, is there an alternative to the LCB by having better co-ordination amongst existing Government Departments?
- Mr Lameck Kawicke noted that the institutional changes proposed were significant and questioned whether these changes could be accommodated by GoSL.
- Mr Clairvair Squires (CDB) made two points:
 - How to prioritise the actions required and/or what is the time frame for implementation - must match the plan with the available resources (*these issues may become clearer after presentation of the Development Plan*)
 - How to rationalise the movement of persons from Government service to a Board (*Has been done in the past without too much trouble*)
- Dr Julius Polius suggested that alternatives to the proposed institutional arrangements should have been considered.
- Mr Lameck Kawick Asked if there was any conflict between the proposed role of the LCB and the Development Control Authority and the provisions of the Crown Land Act (*No*)
- Mr Clairvair Squires (CDB) noted that the NW Coastal Conservation Project had started in January 1998 (ie after submission of the WEMP Draft Report) and that many of the objectives of the two programmes were similar (*Assured that the objectives were complementary - see Section 3.7 of the Main Report*)
- Hon Cassius Elias (Minister of Agriculture) enquired about the prospects for irrigation (*Very poor, but limited irrigation in a 1-2 watersheds may be possible for high value horticultural crops*)
- Mr John Haine (leader of a 2 person team studying irrigation prospects) confirmed the study findings and stated that it was unlikely that sufficient base flows were available at the time when irrigation was most needed. Lack of data was hampering investigations.

3.6

Proposed Development Plan was presented by Peter Thompson HTS following the coffee break. The main features of the plan are based on three components which are interdependent

- GoSL commitment and a sufficient recurrent budget;
- availability of funds for capital and maintenance works in the watersheds which might involve loans or some form of external funding;
- possibility of some grant aid particularly for special studies.

A series of 10 OHP transparencies were presented and the Chairperson requested a response from the following

a) Response from GoSL - Dr Julius Polius Spoke on behalf of GoSL:

- Commended the Consultants on their work and expressed the GoSL view that the ToR had been fully addressed.
- Stated that the Consultants had collected adequate data, identified the main problems and proposed appropriate solutions.
- Accepted that there were remaining deficiencies in the knowledge base.

- Regarding the trials programme the GoSL view was that the engineering and bioengineering trials were of a long term nature and that continuing monitoring was necessary before final conclusions could be evaluated. Regarding the trash management trials it was agreed that action was necessary in view of heavy soil losses, but pointed out that this was contrary to current GoSL advice of bare ground under bananas. He also drew attention to likely farmer resistance to the costs involved in mulching and the impeded access to banana fields caused by the trash lines. He suggested that the conclusion drawn by the Consultants were perhaps premature and noted that work on vetiver grass strips (Harris) had not been recommended. (*Vetiver grass is of very limited use in banana fields -see Section 5.3.2 of the Main Report*)
- The community Participation trial at Dennery was commended, but it was noted that momentum had been lost since the Consultants departure.
- The Consultants review of the institutional framework was adequate, but GoSL was not entirely convinced that the LCB was the ideal institution to implement the development plan.
- The inclusion of a Water Resources Management Unit within the framework of the Development Plan could be useful. (*Report proposes a River Management Unit within LCB - see Figure 7.4 etc of the Main Report*)
- Progress with institutional development was dependent on GoSL commitment and budgetary support and there were reservations with regard to proposed changes in the role of AESD.

b) Response from World Bank - Mr Sam Wedderburn spoke on behalf of the World Bank and highlighted the WB role in project preparation following TSD and the support given to the Phase 1 programme:

- Phase 1 works were completed on schedule and only 15% of these works were subsequently damaged during the 26th October 1996 storm.
- The Bank had proposed the two stage approach ie. immediate repairs and a longer view of sustainable management (Phase 2).
- The Consultants have fulfilled the ToR well and given a comprehensive analysis of data.
- Returning to an earlier theme, the lack of analysis of environmental solutions and cost/benefit analysis was regrettable as was the absence of development alternatives.
- On proposed changes to farm practices on steep slopes and it was thought that insufficient analysis at farm level had been attempted and thus assistance to farmers was poorly quantified.
- The Community Participation Programme was commended, particularly as it provided an excellent tool for necessary public awareness of environmental problems.
- Approved of the proposed development strategy, in that it provided a framework for future development and stressed that GoSL commitment and adequate funding were the keys to success.
- Finally noted that in earlier meetings GoSL had indicated that it would not seek further WB funding for WEMP and would prefer to access Stabex funds.

c) Response from DFID in the Caribbean - Mr Dick Beales

- Expressed thanks to those responsible for arranging the workshop and said that delays had, in fact, made the timing of the workshop quite appropriate - this was of particular relevance to the recent WTO decision on bananas and the pressure imposed on the economy of St. Lucia.
- DFID was increasingly taking an holistic view and was promoting whole island management systems.
- Referred to staffing changes which had occurred after the elections and the difficulties this had caused.
- Referred to the UK Government White Paper in as far as it affected aid policy.

- Briefly explained the WEMP logical framework:
 - DFID's expectations of the project had been met;
 - GoSL expectations were largely fulfilled;
 - the Consultants had met the project objectives.
- DFID was encouraged by the Prime Ministers comments and the need for environmental management.
- Interested in comments made by potential donors particularly CDB.
- The regional implications and possibilities from extrapolating project findings to other Islands through OECS were interesting.
- Appreciated the feedback that the workshop provided in guiding DFID in future project development and generally improving its performance.
- Agreed with the WB that further economic analysis was needed.
- Disappointed at the lapse in support for the Dennery WMAF.

3.7 Open Discussion

Main points raised were:

- Mr Rod Matthews (DFID) reiterated the earlier point regarding the need for economic analysis and suggested that the project approach could work against the long term sustainability of WEMP - at the end of five years everything tends to stop.
- Mr Sam Wedderburn (WB) agreed with the previous speaker and suggested that the latest WB initiative of "Learning and Innovation Loans" could be more appropriate to the circumstances facing GoSL in the implementation of WEMP
- Ms Alison King-Joseph (Chair) asked whether the Land Bank proposed in the report was based on experience and was a workable proposition (*Yes, but the problem in St. Lucia was the absence of Crown Land for agriculture - most of the suitable land is in private hands. As the WMAFs develop it may be possible to identify solutions on a case by case basis*)
- Mr Calixte George (CDB) stated that better links with similar projects and existing organisations should be explored.
- Dr James Fletcher (PS Agriculture) questioned the proposed change in the role of AESD maintaining that mechanisation, part of AESD's present brief was not being done due to a lack of resources.
- Dr Vasantha Chase (OECS) it had been intended that OECS should wait for the completion of the HTS study and then assess the potential for using the St. Lucia model in other islands. However, due to pressure from other islands OECS had made a start with developing watershed management initiatives. The approach was slightly at variance to that proposed by the Consultants and OECS were extremely interested in studying the WMAF at Dennery and looking at alternative structures

4 RECOMMENDATIONS OF THE MEETING

It was agreed that there was no further need for comments on the Draft Report and the views expressed at the workshop should be recorded as Proceedings of the Meeting and annexed to the Final Report.

The Consultants undertook to produce the report within the specified period

GoSL stated that:

- Whilst accepting the report they retained the right to decide which of the recommendations it felt appropriate.
- Agreed that a start should be made on the two pilot watersheds along the lines proposed in the report.
- Needed more time to study the implications of the development proposals and further dialogue was planned.