PN-AAP-549
ISN 3[illegible]2

Dominica

An assessment of small hydropower potential

NRECA Small Decentralized Hydropower (SDH) Program

Dominica: An assessment of small hydroelectric potential

By Walter Lawrence, Jeff Folts, and Keith Oberg

January 1982

Sponsored by the United States Agency for International Development under Cooperative Agreement AID/DSAN-CA-0226

Small Decentralized Hydropower (SDH) Program
International Programs Division

National Rural Electric Cooperative Association (NRECA)
1800 Massachusetts Avenue NW, Washington, DC 20036

Small decentralized hydropower program

This publication is one of a series that fosters the effective use of small decentralized hydroelectric power systems. The series is published by the Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association (NRECA). NRECA operates the SDH Program under the terms of Cooperative Agreement AID/DSAN-CA-0226 with the Office of Energy, Science and Technology Bureau, U.S. Agency for International Development.

Under the agreement, begun in May 1980, NRECA provides a broad range of technical assistance to developing countries. NRECA provides such technical assistance by--

- Designing and implementing regional workshops in Africa, Asia, and Latin America
- Scoping and managing in-country resource surveys and site assessments
- Providing engineering, design, supervision, and specialized assistance
- Developing specialized publications, such as state-of-the-art reports, inventories of manufacturers, and assessment methodologies
- Conducting special studies into subjects of finance, management, and evaluation
- Providing training services in such topics as operation and maintenance, resource assessment, management, and fabrication
- Carrying out specialized services, such as tours of U.S. manufacturing plants
- Creating specialized products, such as productive-use plans for energy from small decentralized hydropower.

For more information on the SDH Program, please contact:

Information Specialist
Small Decentralized Hydropower Program
International Programs Division

NRECA
1800 Massachusetts Avenue NW
Washington, DC 20036

Telephone: 202-857-9622
Telex: 64260
Cable: NATRECA

Terms of reference

In November 1981, the Agency for International Development (AID) arranged for a three-person team from the National Rural Electric Cooperative Association (NRECA) to conduct a study of the potential for the development of small decentralized hydropower in Dominica. In the performance of this study, the team, which consisted of an electromechanical engineer, a civil engineer, and a social-economic adviser was to--

Identify small decentralized hydropower (SDH)* sites (on the lesser developed eastern side of the island) in areas that are expected to remain outside the reach of the centralized power system

Select at least six of these sites for additional investigation

Recommend the location of six river stage-gauging stations to provide basic hydrologic data for future water resources development. This was to be done in close cooperation with a member of the Caribbean Meteorological Institute (CMI)

Determine the feasibility of installing a grid-connected small hydroelectric powerplant (approximately 50 kW) at the Antrim waterworks near Roseau

Information presented in this report is intended to assist the government of Dominica and the Caribbean Development Bank (CDB) in making basic decisions in the continuing program to develop Dominica's hydroelectric potential.

The full terms of reference for the small hydro team appears in appendix A.

Methodology and criteria for site selection

The government of Dominica assigned the NRECA team six nonelectrified east coast and inland areas to consider for potential small decentralized hydropower development. (See appendix B).

*NRECA has adopted the acronym of SDH for Small Decentralized Hydropower projects. Many agencies use the terms "micro-hydro" or "mini-hydro," neither of which has a specific definition. These three terms are used interchangeably herein.

The NRECA team made an initial map survey of the assigned areas using official 1:25,000 scale topographical contour maps obtained from the government's Lands and Surveys Office. The team selected 11 possible sites using the following general criteria:

Contours suggesting sufficient head, or fall, in the river for the generation of electricity

Accessibility for the introduction of projected civil works

Proximity of potential significant demand centers

Indications of significant, year-round water flow as suggested by size and altitude of catchment area, length of stream and its tributaries, and nature of land use in the catchment area. To these criteria the team added hydrological data, where available and deemed reliable.

Following the site selection process, the team, accompanied by officials of the Forestry Development office visited the sites.

Findings and recommendations

The team found that the east coast of Dominica has the physical attributes required for small decentralized hydropower. Economic and institutional issues present the major obstacles to implementing an SDH program.

The major recommendations are summarized below.

1. East coast sites. The government of Dominica should--

Decide how, and to what extent it is willing to subsidize electrification

Plan for additional productive investments (housing, social services, and industry) in areas with potential for electrification so that electrification will be part of an integrated rural development project.)

See recommendation 4, below, for related discussion of the institutional context.

2. Antrim. The existing pipeline to the Antrim site is too small, and resultant head loss too high, to produce power at a competitive cost. However, the water needs of Roseau eventually may require the installation of a second pipe. Feasibility studies for this second pipeline should include an assessment of its potential for power production.

3. Stream gauging. In the area studied by the team, the most suitable locations for stream-gauging installations are--

Demitrie River at Penville
Raymondstone River above Castle Bruce
O'Hare River at Rosalie
Riviere Blanche at Delice
Riviere Nyson at Petite Savane
Malabuka River at Bagatelle.

4. Institutional issues. To promote east coast electrification, Dominica should--

Consider modifying Dominica Electric Service's (DOMLEC) current exclusive right to market electricity on the island

Tap local resources for planning, constructing, and maintaining electric power systems on the east coast

Support, materially and politically, the current ATI-assisted SDH project at La Plaine

Establish an electrification coordination working group that will integrate the information being developed by public agencies and consultants, and incorporate energy-related plans into area investments sponsored by other agencies.

Details of these findings and recommendations appear in section 11 of this report.

Contents

Executive summary, iii
Terms of reference, iii
Methodology and criteria for site selection, iii
Findings and recommendations, iv

Section

1 Introduction, 1
Terms of reference, 1
Technical terminology, 1
Methodology and criteria for site selection, 2

2 General features--Geology, topography, and hydrology, 4
Geology, 4
Topography, 4
Hydrology, 4

3 Electric supply in Dominica, 8
Transmission, 8
Generation, 10

4 Economic background, 13
Energy consumption in the agricultural sector, 14
Population, 14
Regional socioeconomic background, 15
Economic behavior, 16

5 Site descriptions, 22
Riviere Nyson/Savane River (Petite Savane), 22
Malabuka River (Bagatelle/Fond St. Jean/Pointe Carib), 24
O'Hara River (Rosalie/Grand Fond), 25
Demitrie River (Penville/La Haut), 27
Upper Layou River (Bells), 29

6 Site analyses, 30
Design criteria, 30
Cost estimates, 31

7 Financial/economic analysis, 38
Site analyses, 38
Other financial and economic considerations, 40

8 Combined water supply/electricity generation, 44
Technical analysis, 44
Economic analysis, 47

9 Stream gauging, 50
Sites considered, 50
Stream-gauging equipment, 51

Previous Page Blank

10 Institutional issues, 52
Rural electrification strategy for the east coast, 52
Responsibility for east coast electrification, 52
Community role, 53
Conclusions and recommendations, 55

11 Findings and recommendations, 57
Summary of findings, 57
East coast SDH sites, 57
Layou River/Bells Site, 57
Antrim, 58
Stream gauging, 58
Institutional issues, 59

Appendix

A Scope of work--Dominica, 62
B Letter to NRECA from the Office of the Prime Minister, 67
C People contacted in Dominica, Barbados, and Washington, D.C., NRECA Dominica Small-Scale Hydro Team, November 3-25, 1981, 68
D Energy prices in Dominica, November 1981, 71
E Assumptions for economic analysis, 72

Exhibits

A Monthly rainfall at three stations, 6
B Electric transmission system, 9
C Site locations, 21
D Antrim waterworks, 45

Tables

1 Line costs per mile (1981 base), 10
2 Pole costs, landed in Dominica (1981), 10
3 Existing generating capacity, 11
4 Typical electricity load breakdown by consumer groups, Dominica 1975, 12
5 Dominica exports, 1979, 13
6 Dominica population by age--1970 census, 15
7 Per capita farmland by parish and region, 18
8 Dominica: sectoral income per person employed, 1970, 19
9 Dominica: average per capita income by planning regions, 1970, 20
10 Breakdown of civil works cost estimates, 32
11 Powerplant mechanical/electrical costs, 34
12 Distribution plant costs, 34
13 Total project costs, 35
14 Summary of site characteristics, power potential and costs, 36-37
15 Present values and benefits/costs ratios for selected small hydro sites, 39
16 Antrim capital costs, 47

17 Comparison of costs of Antrim hydroelectricity generation with costs of diesel electricity generation, 49
18 Comparison of costs of Antrim hydroelectricity with costs of diesel electricity generation, 49
19 Gauging sites selected, 51

Section 1

Introduction

In late June 1981, officials of NRECA met with Prime Minister Virginia Charles of Dominica to discuss NRECA's role in assisting Dominica in developing its hydroelectric resources. Following the meeting, Prime Minister Charles wrote to the Agency for International Development requesting a study and implementation strategy for the development of Dominica's hydroelectric system.

Terms of reference

Following receipt of the prime minister's letter, AID/Washington, NRECA, and USAID/Barbados--the latter working in concert with the Caribbean Development Bank (CDB); the Government of Dominica Ministry of Communications, Works, and Tourism; and the Caribbean Meteorological Institute (CMI)--developed a scope of work for NRECA appropriate to the broad objectives requested. As agreed to by these agencies, NRECA provided a team to conduct the appropriate studies. The team's composition, and the focus of its study are outlined in the Executive Summary.

Funding for procurement and installation of the gauging stations and for the grid-connected hydro plant, discussed in the Executive Summary, is under consideration by the CDB. This report is intended to enable the CDB to allocate funds for the gauge installations with a minimum of additional surveying and detail. In the case of the grid-connected hydro-power plant, this report represents the conceptual design criteria and economic feasibility. Design details such as foundations,and reinforcing will require more field and office time than available under the scope of this report.

Technical terminology

British/U.S. linear and volume units are used throughout this report.

Unit	Abbreviation
Feet	ft
Cubic feet	ft^3
Cubic yards	yd^3
Cubic feet per second	cfs
Millions of imperial gallons per day	imgpd
Miles	mi

Electrical units are conventional:

Kilowatts	kW
Kilowatt-hours	kWh
Volts	V
Kilovolts	kV

Monetary units are specific:

U.S. dollars	$
East Caribbean dollars	EC$

($1 = EC$ 2.69)

Methodology and criteria for site selection

Following conversations with the prime minister's staff and the minister for communications, works and tourism, and in accordance with general areas designated in a letter dated November 13, 1981, from the office of the prime minister, the NRECA team identified six nonelectrified areas in which to search for small decentralized hydro sites.[1]

Northeast Coast above Vielle Case
Atkinson/Carib Reserve
Saint Saveur/Good Hope/Petite Soufriere
Rosalie River Valley including Grand Fond, Riviere Ciriques, Morne Aux Fregates, and Morne Jaune
Petite Savanne
Bells/Dleau Gommier Forest Preserve.

Four potential sites were deemed "off-limits" to NRECA investigations:

Castle Bruce
Delices
Grand Bay
La Plaine.

Dominica previously allotted site identification in these regions to Canadian Energy Development Systems International (CEDSI) and to Appropriate Technology International (ATI).

Using the methodology and criteria outlined in the Executive Summary of this report, the NRECA team selected 11 potential development sites:

Layou River/Bells
Layou River/Dleau Gommier
Demetrie River/Penville
Rosalie River/Rosalie-Grand Fond Road

---

1 A copy of that letter is included as appendix B.

O'Hara River/Rosalie-Grand Fond Road
Stuarts River/Gueule Lion
Brown's River/Newfoundland Estate
Riviere Ciriques/Rivere Ciriques
Savane River/Petite Savane
Riviere Nyson/Petite Savane
Malabuka River/Bagatelle Estate.

As noted in the Executive Summary, the team visited the selected sites in the company of staff members from the Forestry Development Office and the Office of Local Government and Community Development. These staffs also helped in planning the visits. Team engineers analyzed each site, estimating head; streamflow; diversion intake, turbine-generator and penstock placement accessibility for construction; and length of necessary transmission lines. The team's socioeconomic adviser analyzed available census and other socioeconomic data for each area; interviewed village council members, local government staff members, villagers, and other key informants. He also observed socioeconomic activities in the area that appeared relevant to construction and maintenance of proposed SDH facilities and potential demand for electricity.

Cognizant of the limited time available for field visits, the team decided not to visit several nonelectrified east coast communities. These included--

Boetica. Boetica has a small population (374), which actually declined since 1970. Its catchment area was judged unlikely to maintain year-round streamflow.

Atkinson/Salybia/Carib Reserve. The NRECA team understands that some interest in electrification exists among the Carib population. The community reportedly has sent information on river head to ATI's mini-hydro consultants. Significant mutual help and community activities exist, including a furniture factory, a coconut-processing plant, and cottage industry handicraft manufacture. However, as with Boetica, maps indicate that the catchment area is insufficient to justify a mini-hydro installation, although it might be ample enough to provide for a micro-hydro development that could supply electricity to a few families.

Section 2

General features--Geology, topography, and hydrology

Geology

The geologic history of Dominica is marked by two main events. During the Cretaceous and Eocene periods, the mountains of Central America and Mexico, as well as the Caribbean coastal range from Colombia to Barbados, were formed. At this time, Dominica was under water, and thick marine deposits were laid on the submerged island. In the late Miocene and early Pliocene periods, the island chain from St. Kitts in the north to Grenada in the south was formed by considerable faulting, folding, and tilting of the smaller island land masses. The island of Dominica, in contrast to some other islands in the chain, is still volcanically active as evidenced by Boiling Lake and substantial geothermal activity. The rocks of Dominica, resulting from these events comprise three general types: (1) older volcanic rocks, (2) marine deposits, and (3) later lava flows and recent deposits. In the wettest parts of the island the older volcanic rocks have weathered to produce a red clay material. The marine deposits consist of tuff, gravel, and limestone.

The susceptibility of Dominica to seismic activity poses a constraint to development of high dams. In addition, geologic conditions in concert with very steep, rugged topography and heavy rainfall make certain areas of the island particularly vulnerable to landslides. These factors need to be considered carefully in relation to location, design, and long-term stability of canals and other civil works.

Topography

Dominica is characterized by extreme relief, with highly dissected terrain and deep, narrow river valleys. There are very few flat or gently rolling areas on the island. Elevations range from sea level to 4747 feet atop Morne Diablotin. About half the total land area lies at elevations above 1000 feet. East-flowing stream profiles drop most precipitously from the mountains in the interior and flatten somewhat toward the coast. As a result, many of the potential small, high-head hydro sites that initially appear worthy of consideration have major drawbacks. Such sites are several miles from the coast and are inaccessible, or nearly so, because of formidable topography and the absence of roads.

Hydrology

Dominica has a marine tropical climate characterized by a wet season from May to December and a dry season from January to April. However, rainfall may deviate significantly from this

general pattern. For instance, several government and DOMLEC officials expressed the opinion that rainfall and runoff during the first half of November 1981 have been much lower than normal, with observed streamflows approaching levels characteristic of the dry season. On the other hand, rainfall and streamflows during the usually dry season in early 1981 were higher than expected.

Rainfall over the island generally increases with increasing elevation and varies over a wide range, from 70 inches or less per year at points on the west coast to more than 200 inches around the highest peaks. On an area basis, the average precipitation for the whole island is about 175 inches per year. Most of the rainfall records in Dominica are for stations fairly near the coast, at elevations of a few hundred feet or less, and having average annual precipitation of 150 inches or less.

Rainfall is higher on the east coast of Dominica than on the west coast. (See exhibit A.) Further, according to Marc Blanc of the Ministry of Agriculture, rainfall distribution in higher rainfall areas is generally more uniform throughout the year than in areas that have less precipitation. The more uniformly distributed rainfall can be expected to contribute to higher and more sustained minimum flows in streams draining the higher elevations.

Streamflow data for Dominica are very limited. As far as can be determined, no records exist for rivers that drain to the east coast. Apparently, the only available information consists of (1) one year of daily discharge measurements for the Check Hall River (June 1956 through May 19, 1957), (2) about 8 months of periodic measurements for the Roseau River near Trafalgar (August 1956 through March 1957), and (3) flow records kept in connection with operation of the Trafalgar Falls and Padu hydroelectric stations. These three rivers flow to the west.

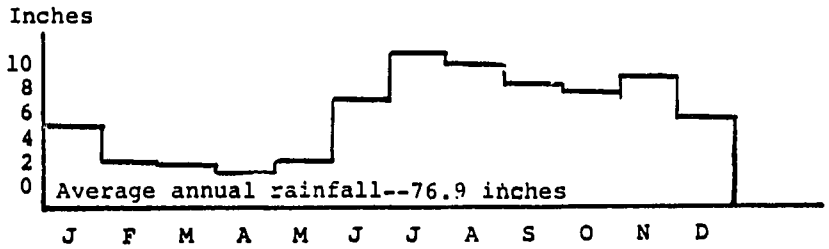
The lack of data on streamflow, evaporation and transpiration losses, and groundwater contributions to base flow, make estimates of flow and flow duration conjectural at best. For purposes of this report, average discharge for potential hydro sites was estimated on the basis of average annual rainfall over the catchments and assumed a rainfall loss of 50 inches per year. This figure is from the 1975 annual report of the North of Scotland Hydroelectric Board (NSHEB) and was determined by analyzing climatically similar locations throughout the world.

The NSHEB report included a generalized flow-duration curve useful for preliminary hydroelectric planning in Dominica. The curve estimates minimum streamflows at 20 percent of average. Without actual field measurements of streamflows, the applicability of such a flow-duration curve is uncertain. The team's feeling, however, is that the NSHEB curve may be somewhat conservative and that low flows, particularly on the east coast, may be sustained

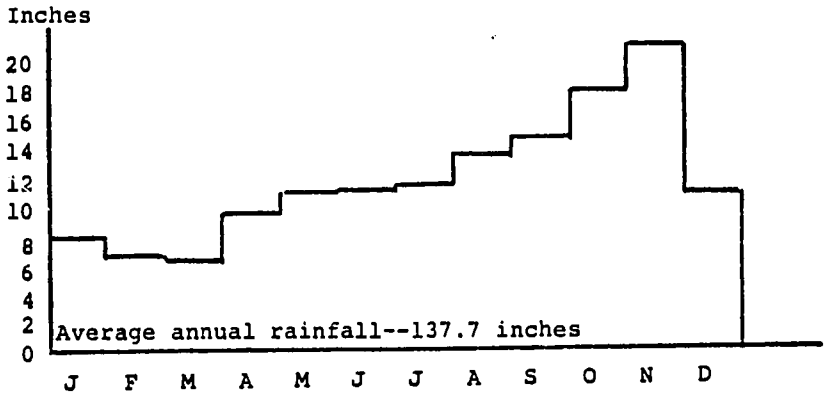
Exhibit A

Monthly rainfall at three stations

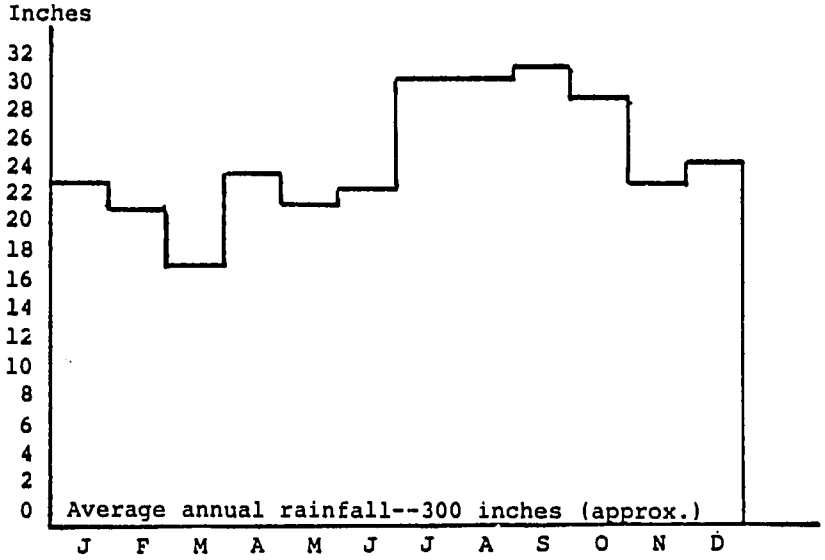
Typical west coast station (Botanic Gardens, elev. 60 feet)



Typical east coast station (Rosalie, elev. 100 feet)



Typical central high station (Fresh Water Lake, elev. 2500 feet)



at higher levels during dry periods. Again, data collection is essential to characterize stream response under varying conditions.

The installation of stream gauges as recommended in section 9 of this report will provide valuable flow information and allow greater accuracy of hydrologic analyses in the future for small-hydro and for other water resource planning.

Estimates of installed capacity and energy generation have been based generally on average streamflow and a duration curve similar to that in the NSHEB report. Refinement of these probably conservative estimates must await collection and analysis of field measurements. Since it has been decided to use turbines with flat efficiency characteristics over a wide range of flows wherever possible and to install machines capable of capturing a high proportion of the flows available, the projects are not overly sensitive to variations in streamflow. Thus, the estimating procedure is considered adequate for prefeasibility planning purposes.

Section 3

Electric supply in Dominica

Central station electric service on the island of Dominica is provided by DOMLEC, which presently is majority owned and managed by the Commonwealth Development Corporation (CDC). While the government of Dominica now has the minority ownership, government ownship is scheduled to increase to 51 percent through aquisition of CDC's shares by 1982.

Since 1975, the island power system has consisted of three separate subsystems. One system provides power for the west coast, from Scott's Head in the south to Portsmouth in the north, another for the area around the northern town of Blenheim, and the third for the northeastern area surrounding Melville Hall, the site of the country's major airport. Prior to Hurricane David in August 1979, these subsystems were inter-connected, but the hurricane devastated many sections of the 11-kV transmission systems. The generating stations also sustained considerable damage but, fortunately, the major civil works of the hydropower plants escaped damage except for one penstock, which was partly crushed by a falling tree.

Transmission

DOMLEC had done a creditable job of restoring its system after the hurricane, although at this writing a few transmission gaps remain. By early 1982, these are expected to be closed. Accordingly, for the purpose of hydropower sites discussed in this report, the west coast and northeastern systems will be interconnected. Exhibit B shows the system as it should appear in the near future. The indicated lines are 11-kV, three-phase, delta connected. Most are supported by single wood poles with a single crossarm and pin insulators. Given Dominica's topography, most of the 11-kV line poles are on steep hillsides. This is true even where the lines parallel the roads, because many of the roads were cut into the hillsides. Almost all elements of installation, from hauling to digging (often in rock) to stringing conductors are difficult in this type of terrain. Thus, line costs will be exceedingly high. Shown below are the unit costs per mile for various line configurations for a typical mix of single pole, dead-end, long-span and specially guyed structures. These figures are drawn from DOMLEC's experience.

EXHIBIT B
ELECTRIC TRANSMISSION SYSTEM

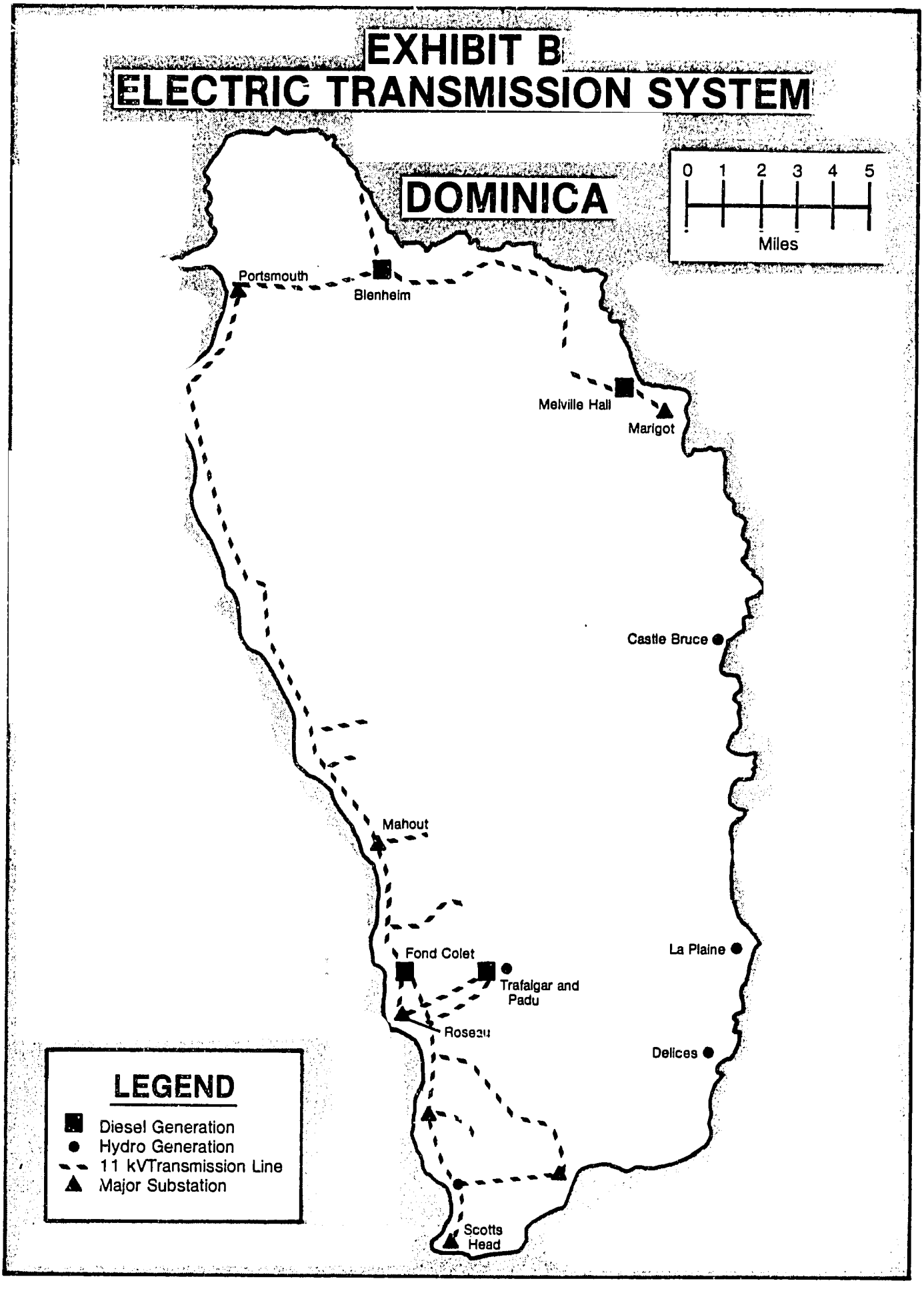


Table 1

Line costs per mile (1981 base)

Type	EC dollars	US dollars
11 kV single-circuit, 3 phase	75,000	27,900
11 kV single-circuit, 3 phase with 400 volt, 4 wire under-build	105,000	39,000
400 volt, 3 phase 4 wire	70,000	26,000
400 volt, 2 phase 3 wire	60,000	22,300
230 volt, 1 phase, 2 wire	50,000	18,600

Poles are imported from Guyana and recently have cost DOMLEC as follows:

Table 2

Pole costs, landed in Dominica (1981)

Type	EC dollars	US dollars
40' butt treated	413	154
30' butt treated	220	82
40' fully treated	598	222

DOMLEC builds its lines by force account since there are no qualified contractors on the island. Work is labor intensive--common labor is plentiful and it is impossible to get mechanized construction equipment to most line locations.

Generation

The DOMLEC electric system is basically run-of-river hydro with diesel generation added as needed during times of low water or peak demand. At present, there is no water storage on the hydropower system. Furthermore, while Dominica expects to begin operation of a new hydro plant, which will draw water from Freshwater Lake, in 1985, the 300-kW capability of this plant will be too small to offset seasonal variations in the generating patterns of other hydro installations. This is evident from an examination of the following list of generating capacity, including diesel:

Table 3

Existing generating capacity

		Station rated capacity (kW)	Station derated capability (kW)
Hydro			
Trafalgar	3 x 320	960	960
Padu	2 x 940	1880	1560
	Subtotal	2840 (43%)	2520 (42%)
Diesel			
Trafalgar	2 x 265	530	400
Fond Cole	1 x 529		
	2 x 1126	2781	2652
Melville Hall	2 x 110		
	1 x 250	470	450
	Subtotal	3781 (57%)	3502 (58%)
Total generation		6621 (100%)	6022 (100%)

Although diesel power (kW) capability is about 58 percent of the total system's capability, the diesel energy output (kWh) under normal conditions is only 10 percent of the annual total energy generation, with the balance being hydro generation.

The relevance of this to small decentralized hydro is that some of the river systems and sites on the eastern side of the island may have hydro potential in excess of that required for the local areas. This excess energy could be absorbed by the central system if the transmission system were more extensively developed and within reach of the hydro site(s). The DOMLEC system characteristics are relevant also to the proposed small hydro-generation at the Central Water Authority Roseau waterworks near Springfield Estate. This feature will be discussed in more detail later.

Table 4 shows electricity use by consumer groups.

Table 4

Typical electricity load breakdown by consumer groups, Dominica 1975

Consumer groups	Percentage of kWh used
Industrial lighting	5
Industrial power	7
Domestic	52
Commercial	33
Street lighting	3
	100

This breakdown is for the total users on the system as of 1975. The team expects that, due to the lack of industrial and commercial development, the category percentages on the east coast are even more skewed toward residential consumption than for the island as a whole.

Section 4

Economic background

The island country of Dominica (area--300 square miles; 1981 population--74,089) is struggling to develop beyond a subsistence agricultural economy. It is handicapped by limited capital, technical, and human resources and an underdeveloped infrastructure. Adding to these substantial limitations have been recent natural setbacks, particularly hurricanes David and Frederick in August 1979 and the incidence of banana leaf spot disease in 1978. The result has been a diversion of resources to emergency activities and a continued stagnant, even declining, economy over the past 2 years.

The country's economic performance during the 1970's was generally poor. Dominica's gross domestic product (GDP) actually decreased from EC$107.5 million (US$40 million) in 1972 to EC$90.4 million (US$33.7 million) in 1977. The island runs a chronic balance of payments deficit due to its limited local productive capability. Between 1975 and 1977, consumption averaged 97.5 percent of GDP, implying a domestic savings rate of only 2.5 percent of GDP. The economy has become literally a subsistence economy, too poor to promote savings and with too little to invest. Its poverty and consequent inability to generate sufficient domestic public sector revenue to match expenditures has forced the country to rely on international grants and soft loans.

The economy is overwhelmingly agriculturally-based. The World Bank reported that in 1979 agriculture contributed 38 percent of GDP, manufacturing 4 percent, and other activities, primarily services, the remainder. Exports are primarily agricultural. (See table 5.)

Table 5
Dominica exports, 1979

Product	US $Millions
Bananas	4.4
Toilet and laundry soap	1.7
Coconut products	0.8
Citrus fruits	0.9
Total	7.8

The small manufacturing sector is located primarily on the west coast in and near Roseau. Most enterprises are locally-owned, use simple technology, are low energy consumers, and are labor-intensive. The sector mainly consists of miscellaneous agro-industries (utilizing coconuts and citrus), garments, crafts,

building materials, rum, cigarettes, and soft drinks. The most dynamic industry has been the processing of coconut into soaps (soap recently became the country's second largest export).

Energy consumption in the agricultural sector

Agriculture in Dominica is generally a minor user of mechanical and electrical energy. In 1976, out of nearly 8,000 holdings, only 43 farms of 5 or more acres owned stationary internal combustion engines of any type, only 56 used electric motors. At present, of these, only 24 and 47, respectively, are being used. On the east coast, St. David Parish had no stationary internal combustion engines. St. Andrew Parish had 11 stationary engines and 39 electric motors, all in use. These statistics probably reflect St. Andrew's relatively greater prosperity, and its access to grid power.

Agroindustry is also a low user of mechanical energy. Bananas, the major crop, are washed and packaged in boxing plants that require no energy other than occasional storeroom/office lights and, rarely, water pumps. Coconut is processed into soaps in one large plant on the west coast and north eastern farmers get copra from coconuts using wood fuel or the sun. Other small cottage processing facilities (bay oil, cassava, farine) also use wood as fuel.

Population

Dominica's population has decreased over the past decade as a result of high emigration from the island. Poverty, unemployment reaching 20 percent, and Hurricanes David and Frederick are the primary factors behind the surge of emigration, which has most recently heavily involved young women.

Dominica, thus, is characterized by--

A marked numerical preponderance of males over females in the areas of highest out-migration, including the poorer east coast

A high dependency ratio (i.e., a high proportion of population under fifteen and over sixty-four years of age relative to the economically productive population.) (See table 6.)

Table 6
Dominica population by age--1970 census

Age	Percentage of 1970 population
Under 15	49.1
15-64	45.0
65 and over	5.9
	100.0

The dependency ratio

$$= \frac{49.1 + 5.9}{5}$$

= 122 dependent person per 100 persons economically active

Areas of habitation generally follow the coastline. The sparse settlements in the interim are found in river valleys and along the few roads crossing the island. Internal migration in search of employment apparently is increasing population concentration in the more developed part of the island (that is, Roseau and environs). Reportedly, emigrants from the east coast would return only if services such as electricity, health care, and education were made available.

Regional socioeconomic background

General. The east coast is the most rural, agricultural, isolated, and poorest of Dominica's three regions. (See tables 8 through 11.) The three east coast parishes--St. David, St. Andrew, and St. Patrick--are three of the four poorest constituencies in a country where per capita income in 1980, according to the World Bank, was about US$500. The east coast parishes average from less than half to less than a third of the per capita income of the Roseau area.

Dominican agriculture is characterized by many small farms. Those on the east coast, particularly in St. Patrick, tend to be the smallest. Only one large working banana estate, at Rosalie, reportedly continues in operation. Except for Rosalie, the sites visited by the NRECA team were in communities of small holders.

Infrastructure on the east coast is notably inadequate. The region possesses no secondary schools, only limited health services, no water treatment facilities, no grid electrification south of Marigot, no significant manufacturing activity, and a poor road network. It also includes the last main village on the island, Delices, not served by a paved road.

With certain exceptions notably in Castle Bruce and La Plaine, there is little public or private investment in the area. However, potential industries for the east coast include--

Sawmilling, plywood, veneer, furniture
Processed foods (cassava farine, bread, banana chips, fruit preserves, etc.)
Laundry starch
Dressmaking
Straw products
Cement and building materials
Ceramic pipes and tiles.

The government has designated La Plaine and Castle Bruce as district centers for the region. It intends to build community centers in each of them and, perhaps, a secondary school in one. Additionally, an OAS-sponsored rural transformation project, including construction of 135 houses and possible financing of cottage industries is scheduled for Castle Bruce.

Economic behavior. Households on the east coast exhibit two interrelated economic strategies designed to increase income and minimize risk; (1) a highly diversified cropping pattern, and (2) a labor pattern of "occupational multiplicity."

(a) Diversified cropping pattern. East coast farmers, in general, appear to straddle the divide between subsistence and market farming, producing dasheen (a tuber) primarily as a subsistence crop and bananas primarily as a cash crop. Dasheen and the related yams, sweet potatoes, and tanniers are planted several times a year with the intent of producing a regular food supply. These rootcrops are observed to grow almost everywhere--around houses, beside roads, and in the hills. Left in the ground, the crops keep well and thereby provide some flexibility to the farmer in harvesting them. The cost of growing these is low and no fertilizer is used. Bananas, coconuts, and citrus are grown primarily for the market and secondarily for home consumption. Most small farmers grow at least some of each. The most suitable land, however, is close to motorable roads and hence limited and quite expensive (up to EC$5000/acre).

Other secondary crops specific to certain areas include bay leaf (Petite Savanne), cassava (Delices), plantain, tous les mois, and cinnamon. This complex cropping pattern is an adaptation to the precarious situation of the east coast farmer. Diversification reflects a need to spread risk away from dependence on one crop, with its vulnerability to depressed marketing conditions, disease, or hurricanes. It also responds to the need of the farming household for a mix of cash income and food for household consumption. One observed exception to this generalization about east coast dependence on banana cultivation is the case of Petite Savanne, where the community is highly dependent on the currently depressed bay leaf market.

(b) Occupational multiplicity. Occupational multiplicity also represents a st ategy to minimize economic risk and increase income. The disruptions caused by Hurricanes David and Frederick, the recent downturns of bananas and bayoil prices, and the chronically depressed economy indicate the wisdom of this strategy.

While most east coast residents are full- or part-time farmers, significant nonagricultural activity takes place. A 1981 survey by a French Technical Cooperation team revealed that between Rosalie and Delices, for example, 52 percent of respondents were full-time farmers. Most of the rest farmed part-time; however, 23 percent of respondents claimed commerce as their principal economic activity. NRECA investigations showed that while many part-time farmers received the greatest share of their income and food from agriculture, outside jobs, obtained when possible, supplemented agricultural income. Nonagricultural employment is a source of investment capital for agricultural inputs. For still others (for example, civil servants, merchants, shopkeepers), farming provides a supplement to consumption and/or income in the form of root crops and sometimes bananas.

(c) Recent trends. The east coast obtained motorable access to Roseau only in 1962. However, even before then, the area was still significantly integrated into the Roseau economy, and indirectly into the international market. The population generally subsisted on tubers, but joined the general economy by marketing high-value processed agricultural products that were transported by foot to Roseau through the Grand Fond/Laudat trail or by boat around the south end of the island. These products included cassava farine, tous les mois starch, coffee, vanilla, lime juice, bay oil, and cinnamon. Because of differing climatic and soil characteristics, crops varied according to town. For example, Grand Fond produced coffee and cocoa, La Plaine, bay leaf and plantains, and Delices, cassava, tous les mois, and tannier.

However, recent observers have noted the following changes--

Decreasing differences among villages due to the spread of banana cultivation

Demise of local processing industries

Increased social differentiation among farmers based on access to "fat land" appropriate for banana cultivation.

This has significance for east coast electrification in two ways--

The range of opportunities for productive uses of electricity has diminished due to the demise of local processing industries.

Access to electrification for household use will be significantly affected by the tariff structure adopted as these people are near the lower end of the affordability scale for electric service.

Table 7
Per capita farmland by parish and region

	Total land areas (acres)	population 1970	Farm* holdings (acreage)	Gross land/ capita	Farmland per capita
Region 1: Total	101,968	28,738	38,055	3.55	1.32
St. Andrew	41,692	11,936	19,995	3.91	1.7
St. David	32,740	6,707	10,069	4.91	1.5
St. Patrick	22,536	10,095	7,991	2.23	0.8
Region 2: Total	24,272	6,928	10,221	3.5	1.5
St. John	15,384	5,227	5,553	2.94	1.06
St. Peter	8,888	1,701	4,668	5.22	2.74
Region 3: Total	68,960	33,882	21,888	2.03	0.65
St. Joseph	30,784	6,326	7,484	4.9	1.18
St. Paul	17,264	4,456	5,928	3.9	1.33
St. George	14,584	19,470	6,147	0.74	0.32
St. Luke	2,784	1,633	995	1.7	0.61
St. Mark	3,544	1,961	1,334	1.8	0.7
Grand total					
Dominica	195,200	69,548	70,164	2.8	1.01

*Based on 1971 Agricultural Census

Table 8

Dominica: Sectoral income per person employed, 1970

Sectors	Total Income (EC$1000)	Number of employees	Income per employee	
			EC$	% of Average
Agriculture	11,143	7,720	1,443	85%
Manufacturing, Mining, Construction	6,708	3,420	1,961	115%
Trade, Transport, Services	15,615*	8,322	1,876	110%
Total	33,466*	19,677	1,701	100%

*Excluding rent of dwellings.

Table 9
Dominica: Average per capita income by planning regions, 1970

	Total net income (EC$1000)	Income per person Employed (EC$)	Income per person % of Average	Dependency ratio	Income per capita EC$	Income per capita % of Average
Region I[a] Windward Rural	11,500	1,605	94%	4.0	401	83%
Region II[b] (Portsmouth)	3,516	1,739	100%	3.4	511	105%
Region III[b] (Roseau)	18,450	1,769	104%	3.2	553	114%
Dominica: Total	33,466	1,701	100%	3.5	486	100%

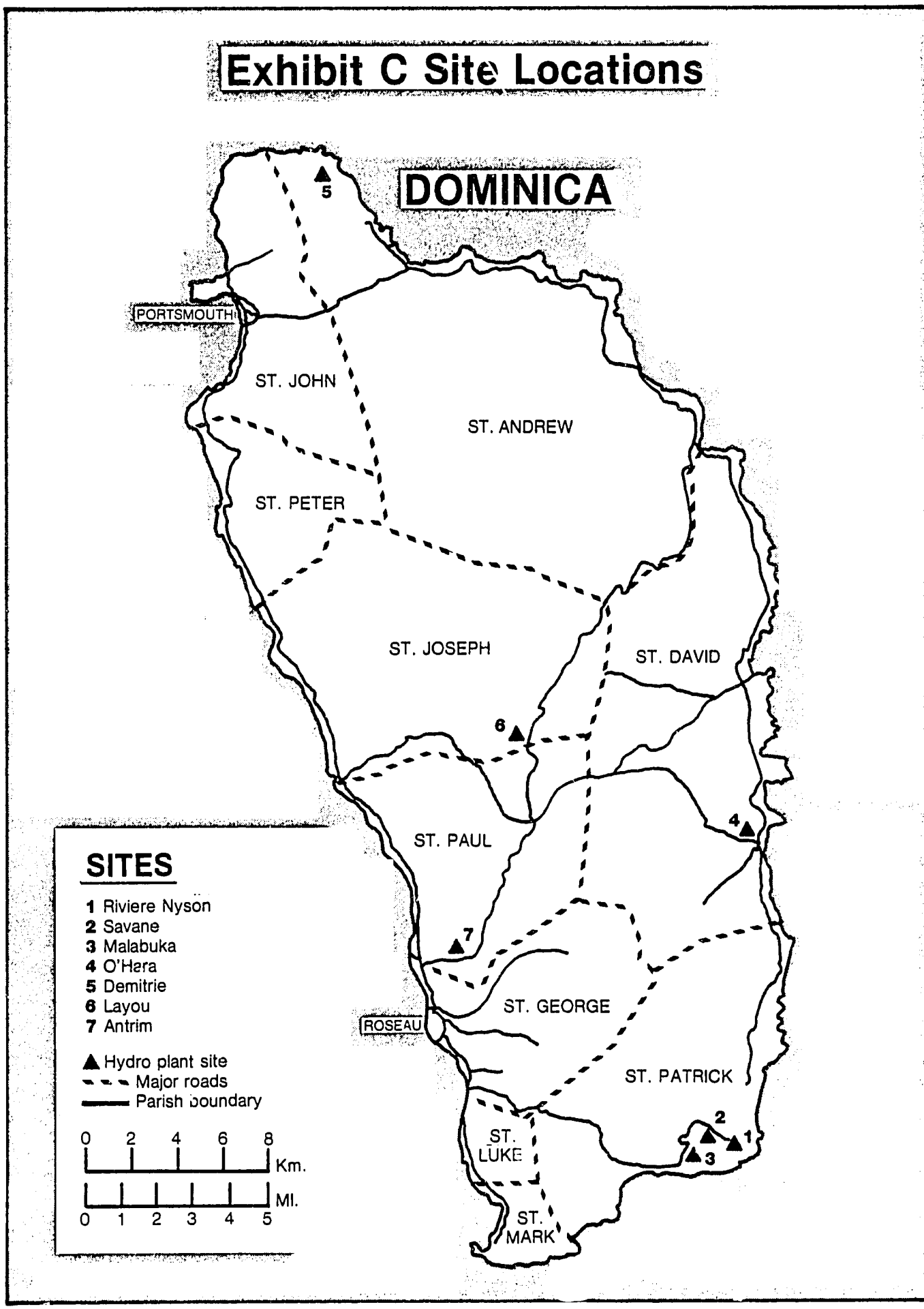
This illustrates the relative backwardness of Region I as compared to the other two Regions. The difference of average income per capita between Region I and Region III is 31 percent. This difference is conservative because of the assumption made above.

[a]Region I consists of parishes St. Andrew, St. David, and St. Patrick.
Region II consists of parishes St. Peter and St. John.
Region III consists of parishes St. Joseph, St. Paul, St. George, St. Luke, and St. Mark.

[b]Dependency Ratio $= \frac{\text{Total population}}{\text{Employed population}}$

Source: Dominica National Structure Plan, 1976-1990.

Exhibit C Site Locations



Section 5

Site descriptions

Socioeconomic background and construction features for each small-hydro site visited are presented in this section. Population figures noted are from the 1981 census.

The sites are--

River	Community
Riviere Nyson	Petite Savane
Savane River	Petite Savane
Malabuka River	Bagetelle/Fond St. Jean
O'Hara River	Rosalie/Grand Fond
Demitirie River	Penville/Demitrie
Layou River	Bells

Construction and financial features of the Antrim (grid-connected) site are discussed in section 8.

Locations of these projects are shown in exhibit C.

Riviere Nyson/Savane River (Petite Savane)

Socioeconomic description. Petite Savane, on the south coast just east of Grand Bay, comprises 149 households with 778 inhabitants. The town is divided into three distinct neighborhoods--Galba, Logiste, and Darroue--in a nucleated pattern with additional lines of houses extended in parallel fashion up three ridges above the river. Both the population and the economy have stagnated in recent times, due in large part to the village's isolated location--it is at the end of an unpaved road from Grand Bay--a low level of public services, and the collapse of the world bay leaf oil market, which in turn led to the suspension of the area's only industry, the Petite Savane Bay Oil Producers Cooperative, Ltd. With the closing of the bay oil plant, the local community's economy became dependent upon a combination of subsistence agriculture (bananas, tree crops, dasheen), petty commerce, fishing for local consumption, and petty industry (such as sewing, boatbuilding, and charcoal-making).

Physical infrastructure is limited. The community has a school and a missionary hall but no other public buildings. A nurse visits twice a month. The water supply has been disrupted since a May 1981 flood destroyed the intake.

A small hydro plant could displace the six existing small diesel and gasoline generators, which range in size from 1.2 kW to 5 kW. These generators, only three of which were functioning at the

time of the team's visit, provide light for households, shops, and, on occasion, community activities at the local school. Small hydro could also displace the kerosene consumption of 13 small refrigerators.

Apart from household demand, significant potential for electrical consumption exists for cold storage for local fish catches, industrial lighting, and other use by a rejuvenated bay oil distillery.

The interest of the village council leadership and the district development officers suggests that the community could play a role in installing stream gauges and small hydro facilities and in operating and maintaining them.

Construction features. Two sites, one on the Riviere Nyson and the other on the Savane River, were investigated for hydro installations to serve the village of Petite Savane and environs. The Riviere Nyson development would entail construction of a low rock masonry diversion dam/overflow section and a gated concrete intake with trashracks near the bridge above the village. From the intake on the left bank, a penstock would be buried on the north (uphill) side of the road that leads through the village and drop downhill to a powerhouse at a point about 310 feet below the intake elevation. The penstock would have to be suspended and supported to cross two small ravines along the route. The alignment along the road was chosen because construction would be easier and because the area's topography is unsuitable for contouring along the hillside and dropping the penstock steeply to the powerhouse. The powerhouse would be situated slightly above the river channel to afford protection from flooding and allow atmospheric discharge from the impulse turbine. The length of the penstock could be varied to change the head and thereby optimize the plant capacity. The system, as laid out with a gross head of 310 feet, would have an installed capacity of 65 kilowatts. Installation would require the construction of a short access road to the power plant site in order to bring in equipment.

The Savane River site was analyzed as a possible alternative to the Nyson site. An advantage of this site is that, except for the short drop to the powerhouse, the penstock could be installed beside the road, thus facilitating construction. However, the site has a smaller capacity (40 kW) and is farther away from the load center. The layout of the site would be basically the same as that for the Nyson site, with a low overflow weir and intake at the road crossing, and a small impulse turbine and powerhouse several hundred yards downstream above the left bank.

The public water supply system that served Petite Savane was heavily damaged by a flood in May 1981 and is currently inoperable. The system had an intake on the Nyson some distance upstream from the bridge where the power intake could be

located. Consideration should be given to combining power and water supply functions to reduce the costs of providing each service separately. The proposed dam and power intake could be designed to accommodate water supply as well. Also, small water distribution lines could be tapped directly into the penstock without significantly affecting power generation potential.

Malabuka River (Bagatelle/Fond St. Jean/Pointe Carib)

Socioeconomic description. The area, bounded on the north and south by ridges running into the sea, has 204 households comprising 896 persons within its approximately half square mile area. Since 1970, the population has decreased 5.2 percent in Pointe Carib-Bagatelle and 13.4 percent in Fond St. Jean-Retireau. About half the homes are distributed along the main road running north-south and a parallel side road. A similar number are scattered along the coast from Point Carib to the Fond St. Jean and Retireau Valleys. Most households are located below the potential hydro site.

The area is agricultural and relatively poor. Landholdings are small. Most are estimated by the district development officer to be under 2 acres. Principal products are bananas, vegetables, straw crafts, dasheen, and, to a lesser extent than in neighboring Petite Savane, bay leaf. A fishing cooperative exists and some fish are marketed locally.

Physical infrastructure is extremely limited. A community hall is used for community activities and, since Hurricane David, as the local primary school. A midwife is locally resident, but there is no clinic. Since the May 1981 flood, the community water supply system has been inoperable.

Self-help activities, mixing paid and volunteer labor (that is, one day paid, next day voluntary), include renovation of the old estate mill for a community hall, road maintenance, and, most recently, construction of a banana-boxing plant. The local government has provided the materials for a once-a-week work session.

The community depends on kerosene lamps and some diesel-generated electricity for lighting and on kerosene-powered refrigerators. Two 3.5-kW diesel generators exist, but only one presently functions, providing electricity for lighting in about ten homes in Pointe Carib at a flat rate of EC$20/month.

Eight kerosene-operated refrigerators (three in small grocery shops, five in private households) currently function in the area. Two electric refrigerators are awaiting eventual electrification. The team observed, or learned of, miscellaneous appliances and several wired houses. Apparently, residents have long been optimistic about linkup to the nearby grid. Potential electricity demand consists primarily of household lighting and

some refrigeration. Potential also exists for a fisheries cooperative cold storage facility.

Construction features. The Malabuka River has a larger drainage area and higher flow than either the Nyson or Savane rivers. The team visited a potential small hydro site at the northern end of the village of Bagatelle. Development would necessitate a low dam and intake structure at a point some 1200 feet upriver from the bridge. A pipeline would convey water from the intake cross-country along the contour and then generally downhill along the road to a powerhouse on the left bank just downstream of the bridge. As was the case with all sites studied, landslide hazards and excessive maintenance requirements make a canal an unfeasible alternative to a pipeline. The penstock route selected would involve about 1500 feet of pressure pipe placement, roughly half along the road and half overland.

Although there was some disagreement, several residents of the area asserted that the Malabuka River never dries up and that minimum flows were probably no less than half that observed on November 16, 1981 (estimated at 5-6 cfs at the potential site and 11-12 cfs downstream at the bridge).

Access to the powerhouse site is no problem since it would be located very near the road. However, reaching the intake site requires some effort. The relatively small amounts of necessary construction material, such as rock rubble or cement, could be obtained at the site of the intake station or brought in by hand or four-wheel drive vehicle.

The possibility exists of combining small hydro with water supply construction, thereby sharing costs of common features and making small hydro more financially feasible.

O'Hara River (Rosalie/Grand Fond)

Socioeconomic description. The Rosalie-Grand Fond area, population 780, is a banana and dasheen-growing region in the center of the east coast. Since 1970, significant emigration, particularly of women, has taken place. Settlement is evenly distributed along the three roads that converge at the mouth of the Rosalie River. The population is concentrated in the Grand Fond-Geuele Lion ridge.

Most of the population are farmers, though many have complementary sideline occupations such as masonry, carpentry, road maintenance, and sewing/tailoring with foot-operated machines. There is some part-time fishing for subsistence and local sale. Land is generally well distributed, with nearly all farms being under 2 acres. The major exception is the banana-producing Roslie Estate.

Physical infrastructure is limited, but above average for the east coast. Grand Fond has a primary school and a clinic as well as a

village council office. A Catholic church is located near Rosalie Estate. A banana-boxing plant operates at the mouth of the Rosalie River.

Rosalie Estate, the only operating private estate, has one refrigerator, two freezers, lights, miscellaneous power tools, and a gas pump powered by a diesel generator. The generator reportedly runs about 10 hours per day. About half dozen small shops depend on kerosene or diesel-powered electric refrigerators. Little private or public investment is expected in the near future.

(a) Demonstrated self-help potential. Several self-help projects have been undertaken in the area recently, indicating the possibility that volunteer labor would be available for small-scale hydroelectric civil works and pipeline installation. Using the proceeds from the post-hurricane sale of building materials donated by USAID, Grand Fond is repairing the local school. Road repairs are also being made on a volunteer basis. The nearby Riviere Ciriques community is building a community hall and repairing roads. In addition, residents are building housing through mutual aid. In Morne Jaune, the community has been stymied in an attempt to install a community water system. After completing the intake, the community lacked the money to buy the required length of pipe.

(b) Interest in electrification. All people interviewed expressed enthusiasm for electrification, characterized by marked optimism about the expected results. With the approval of the residents of Grand Fond, the village council recently drafted a petition to the government requesting installation of a diesel generating plant. So great was the interest that they offered to contribute labor for installation and to pay for maintenance and fuel costs.

(c) Potential village contribution. Apart from payment of electricity tariffs, residents may be expected to provide labor for civil works and transmission lines, through coordination among the village councils, Office of Local Government and Community Development, and Ministry of Public Works. Installation could become an income-generating project, paying EC$14/day to unskilled laborers or instituting some combination of paid and volunteer work as an incentive to participation. One specific suggestion received was that communities would cut, treat with creosote, and install poles using a local wood, carapite, which could lower costs. Although the NRECA team did not technically evaluate this wood, local sources claimed that carapite treated with creosote would last a minimum of five years. (DOMLEC's director disputed this claim, stating that experience with carapite was extremely unsatisfactory). (Useful life of poles normally is expected to be much more than five years -- more like 30 years.)

Construction features. Several streams in the Rosalie area were observed for consideration as potential small hydro development.

The Rosalie River itself is a large stream with considerable water flow, but the relatively low gradient and broad flat valley in the lower reaches makes a diversion dam impractical and would add considerable length to a pipeline. The Browns River tributary near Newfoundland, which flows through a deep, narrow valley, would be inaccessible without major expense in road construction. This fact, along with distance from the populated area, precluded further consideration of the site.

Access to Stuarts River below Gueule Lion was even more treacherous, and the possibility of economical small hydro development on that stream was dismissed. Riviere Ciriques was also visited, but the catchment area does not sustain year-round flow.

The O'Hara River was chosen as being most suitable for small hydro development. Unfortunately, no high-head schemes for using the fairly substantial river flows were immediately apparent. Therefore, a low-head plant was evaluated. The project would consist of a rock masonry dam about 5 feet high, and an integral central spillway section with a crest elevation 5 feet below the main dam abutments. The dam would create a small pool, but storage would be insignificant even for purposes of regulating daily power flow. The dam would be about 700 feet upstream from the confluence of the O'Hara and Rosalie Rivers. A powerhouse containing a single crossflow turbine would be built on the left bank of the river, a short distance downstream from the bridge, and connected to the intake works by a 3560-foot conduit.

The river channel at the dam site is about 30 feet wide, strewn with boulders and rocks, and flanked by a steep bank on the right and only slightly less steep hillside on the left. A dam built at this site would be about 100 feet long at the top. A short access road would be needed to move construction materials to the dam site.

Demitrie River (Penville/La Haut)

Socioeconomic description. The one-square-mile area on the northeast coast in St. Andrew's Parish contains 216 households and about 1000 inhabitants. The population is primarily agricultural, with some fishing for local consumption. The village lies near the end of an unpaved spur of the north coast highway and depends for most of its services on neighboring Vieille Case, a larger town that is integrated into the electric grid and served by a paved road. Penville does possess a small health clinic and a hurricane-damaged primary school.

Self-help activities, directed by the village council, include the present rebuilding of the primary school (which was destroyed by Hurricane David) and the earlier construction of the local water supply system. Several times Penville has requested other public service, particularly roads and electricity.

Households use kerosene for lighting. Most possess from one to three lamps, and wood and some propane for cooking. Six grocery shops own kerosene refrigerators. No generators were seen in the community. Consumption of kerosene for lighting purposes currently costs approximately EC$20/month; for refrigeration purposes approximately EC$75/month.

Potential demand for electricity. Immediate household electricity use would be for lighting, and, in isolated cases, for refrigeration to replace the aging, expensive-to-operate kerosene stove refrigerators. Additionally, some well-off households would likely purchase electric refrigerators. Electrical usage would also stem from radios, irons, and other small household appliances, including hot plates, if reasonably priced. However, given the availability of wood and cost of appliances, widespread use of electric stoves does not seem likely. Productive uses would likely be limited to refrigeration for fish caught locally.

Construction features. The Demitrie River is a small, high-gradient stream that drains part of the eastern side of Bellevue Mountain. The upper catchment provides public water supply to the village of Penville, though the quantities of water withdrawn are small. Villagers stated that the river flows all year long. It is possible that flows in the river may be greater than estimated, since rainfall data for higher elevations on the north end of the island do not exist. The fact that discharge estimated during the field visit (3-4 cfs) is higher than the calculated estimate of average flow, and that field estimates at all other locations compared favorably with estimated averages, suggests one of two possibilities: (1) localized heavy showers produced higher streamflows on the day the Demitrie visit was made or (2) average rainfall over the Demitrie catchment is higher than isohyetal maps suggests. If the latter is true, average streamflow would likely be higher than estimated. In the absence of any other information, preliminary designs have been based on the data as presented.

A small hydro installation on the Demitrie River would comprise a small diversion weir and intake structure in the vicinity of the road crossing, coupled with a 10-inch pipe. Beginning sections of the pipe would be laid beside the road; the rest would follow the contours of the steep hillside that overlooks the river, before dropping down to the powerhouse located on the right streambank about 330 feet below the intake elevation.

Construction would be difficult because of the steep terrain, and care would be necessary to obtain secure anchoring of the pipeline and for preventing landslides. The pipe should be buried in sections where it parallels the contours, even though this would complicate inspection and maintenance. The drop section of the powerhouse could be installed at ground level, so long as firm support could be provided.

Upper Layou River (Bells)

Socioeconomic description. The Bells site lies in the upper Layou River Valley, adjacent to the settlement of Bells. The population of approximately 500 lives in the narrow valley through which the river and cross-island Marigot-Layou road pass. The population occupies a string of houses along a 6-mile stretch of road. The area is entirely agricultural. Families possess between 12 and 20 acres and mainly grow bananas, coconuts, and dasheen. Significant quantities of citrus and occasional sugarcane, coffee, and other tropical crops are also harvested.

Potential electricity demand is low. Fewer than 100 households occupy the area. Facilities include a primary school, a Catholic church, a missionary church (with a diesel engine providing electricity to the complex), a government health center (built but not yet staffed), a banana-boxing plant, and at least four grocery shops. Three of the grocery shops use diesel engine-generators to provide electricity for refrigerators and lights, and one uses kerosene for these purposes. The Forestry Department has an office (the home of the forest warden) at the entrance to the Forest Reserve, and may install a sawmill at the extreme northern end of the valley. An abandoned agricultural experimental center, now used as a residence by local people, may be opened. However, these points are so widely dispersed over the 10-15 km^2 area that distribution costs would be very expensive.

Community energy consumption consists of--

Kerosene for household lighting
Wood and charcoal for household cooking
Kerosene for refrigeration in one shop
Diesel for electricity for refrigeration lighting in three shops.

Construction features. The site on the Layou River below Bells would have potential for low-head development, but the scale of the project is too large for any foreseeable local demand in the Bells area. With a 25-foot dam/overflow section the site would have a capacity on the order of 400 kilowatts. More practically, hydro development in the Layou basin should be planned in terms of larger, grid-interconnected, downriver sites that are closer to demand centers.

Section 6

Site analyses

Design criteria

Several elements bear on the design criteria used for the small hydro plants considered in this report.

Terrain. The generally steep slopes and the dense vegetation of the river courses make the construction and operation of open canals impractical. A canal along a contour on a steep hillside is subject to landslides and the continuous deposit of vegetation and soil debris. Covering the canal would add considerably to its cost.

Geology. Where there is soil cover on hillsides, the dense vegetation helps hold it in place. When disturbed by canal construction, such hillsides become very unstable. In some cases, the soil is shallow and underlain with generally incompetent rock that is not stable when disturbed.

Dams. Rock masonry dams of overflow type can be built with material available at most sites and with local labor. Excavation and cleaning are necessary for adequate and safe abutments.

Water conduits. Terrain and geological limitations indicated above suggest running the pressure pipes to the powerplant along available roads as the most practical solution. Although not an ideal arrangement, this appears to be lower in construction and maintenance costs and more secure against sliding downhill. Inlet works at diversion dams generally could be excavated far enough into the bank to avoid being blocked by rocks washed downstream by flood flows. This may not be necessary where the river gradient is not steep.

Powerplant structure. The placement and height of the turbine above the river channel depends on the type of turbine most suitable for the head and flow available at the site. The impulse-type turbine discharge must be constructed above the highest expected water level. This requirement somewhat reduces the net hydraulic head compared to a reaction turbine, which can be submerged. However, the impulse type is generally favored here.

Site selection. The social, economic, and community aspects of site selection are discussed elsewhere. River profile, water-flow, pipe or penstock routing, access and proximity to loads were considered at this point. With one exception, the above considerations pointed to small diversion dams with pressure pipe-lines generally following roads and leading to powerhouses on a

bank of the diverted rivers. The one exception would have a dam with a small amount of useful storage behind it and a powerplant just below the dam.

Cost estimates

Cost estimates for the six selected sites are presented in this section. They are combined in tabular form.

Civil works. Cost for civil works have been developed from quantity estimates made during field reconnaissance of the sites, applying general unit cost and other data representative of conditions in Dominica. Cost estimates reflect fall 1981 price levels.

Three sets of cost estimates are presented in table 10. The first represents use of steel pipe with welded joints for the penstocks and no local contribution of labor or materials. The second includes use of less costly ductile-iron water pipe with mechanical joints and, again, no local contributions. The third estimate reflects lower costs for all construction items as a result of participation by local people in the labor-intensive portions of the projects and use of locally available construction materials (such as stone) estimated to range from about 15 to 40 percent for various items. Overall project cost savings range from 20 to 25 percent. It is conceivable that greater local contributions could reduce costs further, although the estimates presented are judged to incorporate a level of local participation that could be reasonably expected..

Generation. The turbines for most of the sites can be the impulse or related types. Only the Layou Bells site would require a low-head type turbine--either a crossflow or reaction unit. Other powerplant features were considered standard among the sites. Conventional governors were assumed and electronic load controllers might be suitable, since the sites are run-of-the-river and can run at steady total load--a condition required by electronic controllers. However, the limited cost information available on electronic load controller costs does not indicate any significant savings in equipment costs, except for machines smaller than most of those covered by this report.

Distribution. Unit costs obtained from DOMLEC were used as guides in estimating distribution costs. Although the U.S. urban and rural 7.2/12.5-kV distribution standards could reduce distribution costs considerably if applied here, local experience was considered preferable for costing. In most cases, 11-kV primary was necessary to cover the plant-to-consumer distances. The following is a description of each system and a derivation of distribution costs.

Table 10
Breakdown of civil works cost estimates

Site	Dam and Intake	Pipeline/ Penstock	Powerhouse	Access./ Miscell.	Subtotal	Engineering & Contingencies	Total Civil Works Cost
Steel Penstock, No Local Contribution							
Nyson	8,000	104,000	5,000	12,000	129,000	32,000	161,000
Savane	8,000	72,000	5,000	6,000	91,000	23,000	114,000
Malabuka	11,000	82,000	5,000	8,000	106,000	27,000	133,000
O'Hara	40,000	31,000	9,000	12,000	92,000	23,000	115,000
Demitrie	8,000	56,000	5,000	16,000	85,000	21,000	106,000
Layou	180,000	--	100,000	60,000	340,000	85,000	425,000
Ductile Iron Penstock, No Local Contribution							
Nyson	8,000	74,000	5,000	12,000	99,000	25,000	124,000
Savane	8,000	51,000	5,000	6,000	70,000	18,000	88,000
Malabuka	11,000	66,000	5,000	8,000	90,000	23,000	113,000
O'Hara	40,000	26,000	9,000	12,000	87,000	22,000	109,000
Demitrie	8,000	39,000	5,000	16,000	68,000	17,000	85,000
Layou	180,000	--	100,000	60,000	340,000	85,000	425,000
Ductile Iron Penstock, Maximum Reasonable Local Contribution							
Nyson	5,000	53,000	3,000	10,000	71,000	25,000	96,000
Savane	5,000	37,000	3,000	5,000	50,000	18,000	68,000
Malabuka	7,000	50,000	3,000	6,000	66,000	23,000	89,000
O'Hara	25,000	20,000	6,000	10,000	61,000	22,000	83,000
Demitrie	5,000	28,000	3,000	13,000	49,000	17,000	66,000
Layou	135,000	--	75,000	48,000	258,000	85,000	343,000

Nyson/Petite Savane was used as a model to obtain typical per-house costs in an area of average consumer density. Use of quadruplex secondary was assumed for 400-volt distribution, as it can be strung on drop poles and even house to house. On this scheme, 3/4 mile of 11-kV three phase and 1/4 mile of 11-kV single phase brought the power into the consumer area, and from these duplex single-phase 230-volt feeders fanned out.

Malabuka/Bagatelle is close enough to the source that the 230/400 volts as generated could be carried by doubled quadruplex feeders and tapped off with 230-volt duplex stubs.

O'Hara/Rosalie/Riviere Ciriques/Grand Fond/Geuele is much more spread out than the other systems, involving 2 1/4 miles of 11-kV line with some underbuild at 400 volts, serving perhaps half the houses. Service to the sparsely populated Riviere Ciriques was included in the plan, although it added considerably to the cost of the system.

Demitrie/La Haut/Penville service to Penville covers a fairly densely populated area. Demitrie/La Haut is less populated, and per-house costs would be higher.

Savane River site has no nearby load area, so no estimate was made for this power site.

At 400 kW, the proposed Layou/Bells hydro is not small and the site is far from a load center. Thus, the hydro installed at this site, or preferably one downstream, should be grid-connected.

Cost of distribution for these four sites is summarized in table 12, and the total project cost in table 13.

Table 11
Powerplant mechanical/electrical costs (costs in US dollars)

Site	Equipment in place	Engineering Design	Cont.	Total Cost	KW Rating	Cost per KW
Nyson	73,000	7,000	10,000	90,000	65	1384
Savane River	57,000	7,000	9,000	73,000	40	1825
Malabuka	69,000	7,000	10,000	86,000	60	1433
O'Hara	56,000	7,000	9,000	72,000	56	2400
Demitrie	63,000	7,000	9,000	79,000	40	1975
Layou/Belles	455,000	40,000	50,000	545,000	400	1362

Table 12
Distribution plant costs

Site	Total cost	Cost per house
Nyson/Petite Savane	78,000	523
Malabuka/Bagatelle	82,000	402
O/Hara Rosalie/to Geuele Lion	118,000	590
& Riviere Ciriques	55,000	1666
(Combined total)	173,000	742
Demitrie/Penville	68,000	370
Dimitrie/La Haut	17,000	531
(Combined total)	85,000	394

Table 13
Total project costs - (US dollars)

Site	Civil Works*	Mech/ Elect.	Distri- bution	Total	KW	Costs per KW
Nyson	96,000	90,000	78,000	264,000	65	4060
Savane	68,000	73,000	**	141,000	40	3525
Malabuka	89,000	86,000	82,000	257,000	60	4280
O'Hara	83,000	72,000	173,000	328,000	50	6560
Demitrie	66,000	79,000	85,000	230,000	40	5750
Layou	343,000	545,000	***	888,000	400	2220

* Lowest alternative civil works cost (table 11).

**There is no community within a reasonable distribution distance from Savane. Accordingly, no distribution cost estimate was made.

***Layou, with a potential capability of 400 kW also has no nearby load potential and its size would be appropriate for a central station connected to the grid.

Figure 14

Summary of site characteristics, power potential and cost

River/Community	Drainage area (sq. mi.)	Est. avg. precip. (in./yr.)	Est. observed flow (cfs)	Est. avg. flow (cfs)	Intake elev. (ft.)
R. Nyson/Petite Savane	0.35	170	3	3.1	560
Savane R./Petite Savane	0.28	190	1-2	2.5	940
Malabuka R./Bagatelle	0.64	190	5-6	5.7	420
O'Hara R./Rosalie-Grand	1.52	200	15-20	16.8	90
Demetrie R./Penville	0.29	130	3-4	1.7	910
Layou R./Bells	15.56	250	110-140[a]	229.	595
Check Hall R./Antrim	1.56	200	--	20.7[b]	1,118

[a]Estimated flow at Bells, upstream from site and not including Pagayer River tributary.

[b]Actual flow measured June 1956-May 1957.

[c]Layou site not considered for decentralized service; grid interconnection costs not included.

[d]Assumes lowest alternative civil costs and does not include transmission/distribution costs.

Power-house elev. (ft.)	Installed capacity (kW)	Avg. annual generation (MWH/yr.)	Capital unit cost[d] ($/kW)	Household/commercial load and demand, Year 10 MWH/yr.	kW
250	65	410	2,862	78	18
700	40	250	3,525	78	18
260	60	380	2,916	106	22
45	50	310	3,100	83	18
580	40	250	3,625	110	22
570	400	2,390	2,220	--	--
954	30	190	2,820	--	--

Section 7

Financial/economic analysis

Site analyses

Based on the socioeconomic and technical analyses, the team derived cost and electricity generation and demand figures for the six sites examined. The team's economist selected three of these sites--those judged as most likely to yield favorable benefit/cost ratios--for further analysis. The results are presented below and summarized in table 15. The assumptions used in calculating benefits and in doing the financial/economic analysis appear in appendix E. Benefits were assumed to be (1) revenues (based on DOMLEC's present residential tariff of US$0.13/kWh) and (2) consumer savings resulting from displacement of kerosene by electricity. Future benefits and cost are discounted to present values (PV). Options 1 and 2 mentioned below are quantified in table 15.

Malabuka River (Bagatelle/Fond St. Jean). This site yielded the highest benefit/cost (b/c) ratio of those considered by the NRECA team. Under the assumption of significant donated community labor (Option 2), the present value (PV) of costs over an assumed 30-year project period was approximately US$330,000--US$257,000 in initial construction costs and US$73,000 in discounted operation, maintenance, and repair costs (US$7,700 annually over 30 years). Discounted benefits were calculated at US$301,000 over 30 years. The resulting b/c ratio is 0.91, indicating that expected quantifiable benefits are less than projected expenses.

If all construction labor were paid (Option 1), total project costs would be US$360,500, leaving project benefits unaffected, but producing a slightly lower b/c ratio of 0.83.

Nyson River (Petite Savane). The calculations for this site are slightly less favorable than those for Malabuka River. Under an assumption of donated community construction labor, the PV of costs is US$339,000; of benefits US$254,000. These figures yield a b/c ratio of 0.75. Assuming paid labor produces a PV cost of US$369,000, lowering the b/c ratio to 0.69.

O'Hara River (Rosalie/Grand Fond/Riviere Ciriques/Morne aux Fregates)

This site has calculated discounted costs of US$421,000 (donated construction labor) and US$454,000 (paid construction labor) which, combined with discounted benefits, yields b/c ratios of 0.72 and 0.67, respectively.

Conclusions and recommendations. Under the assumptions made, each of the sites analyzed would likely not generate direct short-term financial and economic benefits sufficient to justify an SDH investment. From a financial standpoint, revenues to be captured by the utility appear to fall far short of loan amortization and operation, maintenance, and repair costs. From an economic standpoint, consumer savings on energy costs--benefits retained by the consumer and not captured by the utility--add significantly to revenues but do not raise the b/c ratio above 1.0.

However, indirect and generally unquantifiable benefits--economic and social--may well justify the investment from the public standpoint. Rural electrification can facilitate economic growth in a region by providing energy for productive use. In particular, it complements additional productive investments--such as an integrated rural development project--that government may elect to make. The economy as a whole, and on a regional basis, benefits through the displacement of petroleum imports, as resources that formerly flowed out remain.

Table 15

Present values and benefit/cost ratios calculated for selected small-scale hydro sites, Dominica (discount factor of 10%)

	Option 1[a]			Option 2[b]		
	PV costs (in 1982 US$ thousand)	PV benefits	B/C ratio	PV costs (in 1982 US$ thousands)	PV benefits	B/C ratio
Malabuka River (Bagatelle - Fond St. Jean	360.5	301	0.83	330	301	0.91
Nyson River (Petite Savane)	369	254	0.69	339	254	0.75
O'Hara River	454	303	0.67	421	303	0.72

[a]Option 1 assumes paid construction labor.

[b]Option 2 includes donated community labor in construction.

Rural electrification can also provide or facilitate health services, education, and an improved quality of life. It aids economic growth by attracting and retaining population.

Government may, therefore, wish to consider investments based on diverse and broader criteria, not just on economic/financial grounds. It may also consider directing additional investments to the areas analyzed in order to raise the load factor and level the load curve. It must be remembered, however, that rural electrification via SDH on Dominica's east coast, as in most rural areas of the world, will require an initial subsidy.

Other financial and economic considerations

Affordability. Affordability is a subjective concept and is thus difficult to measure quantitatively. It is a function of motivation and personal ability to pay for things or services. The NRECA team sought to assess affordability by considering evidence suggesting individual and community desire for electrification and by measuring current expenditures for competing sources of fuels. Given time and information constraints, these provided the best indicators available.

The communities visited appeared highly motivated to obtain electricity. Grand Fond-Rosalie had just petitioned the government for a diesel generator, committing itself to absorb all maintenance and fuel costs. Petite Savane, Bagatelle, and Penville also had previously requested electricity services. A number of residents in Bagatelle, hopeful of grid connection prior to Hurricane David, had wired their houses or purchased electrical appliances or both. At the time of our visit, a limited number of Petite Savane residents were paying a flat rate of EC$10 per month (US$3.45) for energy from a diesel generator to power two lightbulbs apiece.

Presumably most families, whose present energy expenditures are higher than potential competing electricity expenditure, will substitute electricity for the present fuel soon after introduction of electricity. Calculations indicate that at current DOMLEC prices, rural households would save significantly with electrical lighting versus more costly kerosene lighting. The calculations for refrigeration are less clearcut; moreover refrigerator use is limited. However, given electricity's greater convenience and prestige, substitution is likely to take place for that use as well.

Working through the village councils in the planning and implementation of these small hydro projects should also have a positive impact on community interest and motivation, thereby increasing affordability in two ways: (1) increasing hookups contributing directly to total revenues and reducing the need for higher tariff levels, and (2) increasing individual commitment to the success of the project, thus reducing delinquencies.

On the other hand, the current depressed state of the Dominican economy has reduced the rural household's ability to afford electricity. Cash income has apparently decreased. The need to repair homes and farms following the ravages of Hurricanes David and Frederick further drained households of liquidity, as did the repayment of loans contracted earlier. Adaptations by the rural population to these vicissitudes are several: emigration; return to the countryside to plant and live more cheaply, and reduction of cash outflow to the bare minimum.

Under these conditions, it is reasonable to expect electricity demand to be highly sensitive to price. Should the government desire to reach the greatest number of households, it may want to subsidize small hydro and keep tariffs low.

On the positive side, the high emigration of Dominicans to Roseau and the coastal areas in search of employment may be resulting in unmeasured inflows of cash back to the east coast sent by those who have found jobs. Data are unavailable to enable a judgment of the impact of such remittances on family ability to pay for electricity and other services.

Tariff structure for SDH development. In calculating cash flow, the NRECA team utilized the current tariff structure of the utility, DOMLEC, as the basis for calculating revenue. This is arbitrary, of course, and has been done to provide figures for illustrative purposes. In establishing the financial and institutional conditions under which small hydro development may go forward, the Dominican government will determine the desired tariff structure by considering financial, economic, and sociopolitical objectives. For example, to cover projected costs, the government may desire to adjust rates, rejecting a financial analysis approach to pricing. Lower than cost rates may be justified, on the assumption that electricity from small hydro provides money benefits that are distributed to consumers and society in general. For example, electricity for lighting and refrigeration can displace kerosene, saving consumers money, lowering the cost to government of current kerosene subsidies, and displacing expensive kerosene imports (thereby making a modest contribution to easing Dominica's chronic balance of payment deficit). Furthermore, the introduction of electricity would also increase the potential for area economic growth.

Finally, government may desire to subsidize SDH development on political or social grounds. The government should consider use of a modified increasing block rate rather than a flat or decreasing block rate--charging higher per kWh prices to larger users. This pricing structure would increase income by raising taxes on more economically secure individuals and thus provide some income distribution. As power demand increased toward the generation limits, such a structure could be modified to encourage conservation. Household watthour meters would be used to record usage.

4.1 Financial/economic analysis

Projected revenues are generally low in relation to costs, indicating the desirability of building the load (and raising the load factor) through the stimulus of cottage industry and other daytime energy consuming activities.

Planned investments affecting potential electricity demand in the east coast region. The NRECA team's field and background research failed to yield any evidence of significant public or private investments in even small industries in the east coast areas assigned to the team. This suggests that most east coast electricity demand will come from residential and small-scale commercial units.

The team's social adviser assessed demand potential in the area proximate to SDH sites. In general, he determined that initial demand would be low (approximately 30-40 kWh per month per household) and that use would be confined (in the short-and medium-term) to household consumption uses peaking during the evening hours. Initially, productive uses would be extremely limited and slow to develop.

The NRECA team observed several regional characteristics that negatively influence the viability of a rural electrification project: population densities are low to moderate; markets are limited in terms of products and volume; capital and technical skills appear limited, with most resources flowing to and concentrated on the west coast around Roseau and, to a lesser extent Portsmouth. Electrification would probably have an immediate social impact, and contribute to such long-range changes as less-range change in attitudes and emigration, return of emigrants, and increased private and public investment.

Potential east coast industrial and commercial activities. At this point, rates of growth in the industrial and commercial demand for electricity on the east coast are highly speculative. However, several possibilities are apparent.

(a) Timber drying. A project, like the one the Rotary Club is installing at Canefield, would require 32 kW for a solar-kiln dehumidifier and a further 75 kW for other equipment.

(b) Radio station. A station operating at a 25-kW range during the day--a period of low electric system demand--could drop power consumption to 5 kW at night, thereby boosting the load factor and revenues without overloading the system.

(c) Fisheries cold storage. Local fishing in Penville, Rosalie, Petite Savane, and Bagatelle/Fond St. Jean could benefit from co-op freezers each drawing approximately 500 watts.

(d) Bay oil and patchouli distillation. Revival of Petite Savane's bay oil cooperative plant (producing bay oil, patchouli, or both) would boost the local economy and introduce additional

daytime power requirements of perhaps 15-20 kW (industrial lighting, industrial blowers, and hoist).

Other possible uses, which village receiving electrification should consider to increase productive consumption and to level the load by increasing daytime use, include--

Battery charging
Air compression
Heat generation for drying agricultural products (spices, coffee, wood)
Electrical motors for miscellaneous shop uses
Hot water for health clinics.

Section 8

Combined water supply/electricity generation

NRECA was explicitly requested to evaluate in technical and economic terms the potential for modifying the existing Roseau Antrim Waterworks to accommodate grid-connected hydroelectric generation. The concept was that of installing a turbine-generator on the water pipeline to use the energy of falling water to generate electricity. Establishing the compatibility of combined water supply and hydroelectric use, hopefully, would provide a model for application not only in Dominica but elsewhere in the Caribbean.

Technical analysis

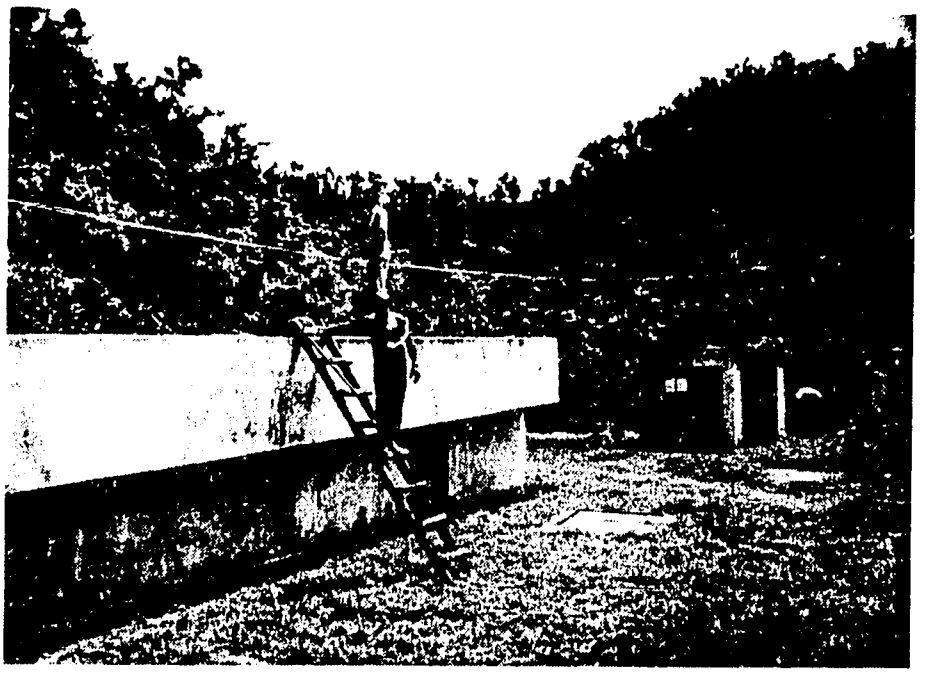
Description. The Antrim Waterworks, on the Check Hall River, is the principal water supply source for Roseau and surrounding areas. Estimated present flow rate is about 5 million imperial gallons per day (igpd). The waterworks consists of a water intake upriver, a 12-inch pipeline 4250 feet long, generally installed beside the road, a settling tank, and a chlorinator (see exhibit D). The elevation above sea level of the intake is 1118 feet, and that of the water surface of the settling tank is 984 feet, resulting in a static differential (head) of 164 feet.

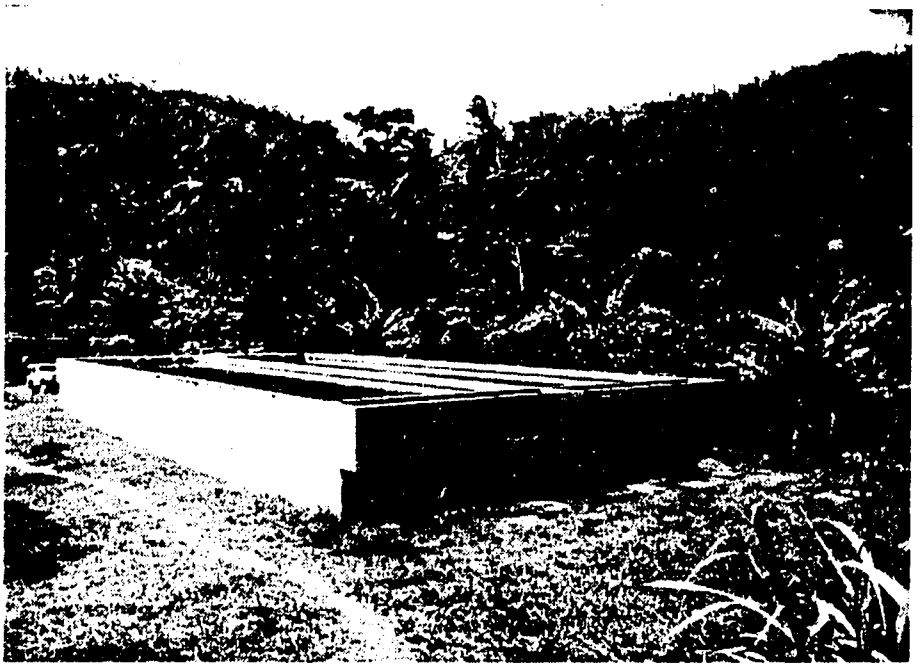
The Antrim system was originally designed and built for the sole purpose of delivering, treating, and distributing a public water supply. Thus, pipeline diameter and alignment were designed only to deliver a certain quantity of water, not to minimize head loss. In fact, certain features of the existing pipeline, such as its small diameter and gradient, were selected to dissipate head and thereby minimize the burden on reducing and control valves that deliver water into the settling tank. Consequently, the pipe is not an optimal water conduit for power generation.

Size and potential generation of turbines. The following methodology was employed to determine the size of turbine and the parameters of potential generation.

The actual pipeline design coefficients, obtained from the Central Water Authority, were used to calculate a series of head loss values at increasing water flow volumes up to the point where water would emerge from the pipe with only velocity head. The results of these calculations showed that the optimum combination of water flow and head occurred at about 125,000 imperial gallons per hour, (3 million per day), resulting in a net head of about 97 feet, and yielding an equivalent turbine rating of about 30 kW. Increasing the flow through the turbine (for example, by increasing its inlet diameter) would only decrease the net head (due to increasing pipe loss) and decrease turbine output.

Exhibit D
Settling tank, Antrim waterworks





Bypassing water around the turbine would also decrease net head rapidly, and turbine output would decrease even more rapidly, due to departure from design parameters.

In sum, operation of the turbine can be a limiting factor. Where water supply needs are greater than at the optimal point described above, a tradeoff is created between power generation and water supply. At present, insufficient information exists to evaluate this potential tradeoff at the Antrim site. No reliable data exists either for daily flow at Antrim or for current and projected water consumption in the Roseau area. Rough estimates put daily flow approaching 5 million igpd and consumption at just under 3 million igpd. If water consumption requirements were to increase to 4 to 5 million igpd, and if water supply requirements were to govern, the turbine could be operated only part-time.

Design recommendations. Basic conceptual design characteristics and approximate costs are as follows:

(a) Turbine: 30-kW equivalent impulse unit, single jet

(b) Governor: Suitable for bringing turbine to no-load speed, then advance jet opening after closing into a set limit. Upon tripping off, governor shall operate deflector and linkage to a bypass, which will be connected to the existing bypass pipe

(c) Induction generator: 35-kVa nominal rating; nominal speed 1500 rpm

(d) Controls: Reverse power, over frequency, over current trip; interlocked with motor-operated valve in water bypass line. There are alternate methods of bypassing water to the settling tank which should be considered. Instrumentation should include kW and kWh integrating meters and a running time meter.

Although it might possible to replace the present nonfunctioning regulating valve and hook the turbine into that, the team considered it better to hook onto the ends of the present bypass valve. If properly planned, the connection could be made in a day and closed off, the turbine piping could be installed without affecting the settling pond. The turbine-generator set would be in an elevated 12 foot x 12 foot concrete structure with room for all auxiliaries and controls. Turbine discharge would be through a 2-foot pipe to the top of the inlet gallery of the tank.

The possibility of generation by water going from Antrim to a pressure break tank near Roseau was ruled out because the pipe carrying this water, is tapped for water deliveries in many places, making it a distribution pipe rather than a transmission pipe. Table 16 summarizes approximate costs for the Antrim installation.

Economic analysis

This economic analysis takes into account the technical analysis and the current plans, generation, and load characteristics of the local utility, DOMLEC.

Table 16
Antrim capital costs (US dollars)

Turbine-generator and governor	$25,000
Control package	10,000
Water conduit material	4,200
Pipe line instrumentation	3,000
Transformer	6,000
Cables, potheads, etc.	300
11 kV disconnect	300
Metering package	3,000
Subtotal	51,800
Powerhouse structure complete	10,000
Tailrace discharge	1,000
Installation of machines, pipes, welding, machine work, etc.	13,000
Upgrade 11 kV tap	2,000
Subtotal	77,800
Contingencies	13,200
Engineering and design	9,000
Total	$100,000

In a typical year, DOMLEC generates 90 percent of its energy from hydro installations and 10 percent from diesel. During periods of dry weather or at hours of peak load (from 6:00 p.m. to 9:00 p.m.) does DOMLEC currently require diesel generation. Only at these times, therefore, would output from the proposed Antrim hydro facility displace diesel and therefore have an economic value.

In addition, DOMLEC plans to have on-line by 1985 a 300-kW hydro installation at Fresh Water Lake. This facility, with significant water storage capacity, would accommodate projected load growth for the remainder of the decade and, in addition, satisfy some of the peaking requirements initially attended by the proposed Antrim scheme. DOMLEC is apparently committed to the implementation of the Fresh Water Lake project. Antrim's small size makes it unlikely it would affect the larger project's construction schedule.

Electricity generation will have to take second priority to water supply concerns at any dual purpose Antrim facility because Antrim (1) is presently operated by the Central Water Authority and (2) constitutes the principal source of water for the island's

major population center. The parameters of the water supply constraint are uncertain, since no reliable statistics exist for current and projected water consumption; however CWA staff members consider 3 million igpd a close approximation. For the purposes of the present analysis, this figure will be used and assumed to be stable through 1985, thus permitting the operation of a 30-kW generating unit capable of producing 240,000 kWh per year. Of course, accurately establishing the current and future water supply requirements of the Roseau area is a prerequisite to implementing the project. The discussions above, and other key assumptions, are documented in table 17. A summary of the results of the analysis is provided in table 18.

Based on available data, it is the team's judgment that hydroelectric generation under present conditions at Antrim is not competitive with electricity generated by diesel. The calculated present value of displaced diesel consumption over the next 30 years is only $53,700. This figure ignores the potential impact of generation from Fresh Water and other potential hydro facilities. This compares unfavorably with the initial cost of approximately $100,000 for installation of hydroelectric capability at Antrim. The impact of generation from Fresh Water Lake would decrease Antrim's benefits even further by diminishing the hydro facility's contribution to fuel displacement.

Accordingly, it is recommended that the government not consider modification of the Antrim waterworks for electricity generation at this time. However, in the event of construction of a second pipeline to accommodate increased water demand, a hydroelectric component may well be feasible. The government and the CWA should determine the existing and projected water demand of the Roseau area over the next 10 years, as well as the capacity of the existing Antrim waterworks. This information is necessary to determine when construction of a second pipeline will be necessary and what type and size of hydroelectric facility might be feasibly integrated.

Table 17

Comparison of costs of Antrim hydroelectricity generation with costs of diesel electricity generation: Assumptions used in calculations

Maximum yearly generation capacity of 30 kW Antrim turbine	240,000 kWh
Projected generation (during daily peak load periods and during dry months)	72,000 kWh/year
Initial cost of diesel fuel	US$.05/kWh
Yearly increase (in real terms) of diesel price	4% year 1 - 30 0% year 31 - 50
Initial Antrim capital cost	US$100,000
Initial diesel capital cost	US$0.00

These costs assume the use of existing equipment. Also, replacement of diesel equipment will take place whether or not the Antrim system is implemented due to the hydro facility's small size--it is therefore not counted.

Maintenance costs	Assumed equivalent

Table 18

Comparison of costs of Antrim hydroelectricity with costs of diesel electricity generation: Results of calculations

Discount factor	10%
Present Value of Antrim costs	$100,000
Present Value of Antrim benefits (equivalent to net present value of diesel fuel displaced by Antrim generation	$53,700 (years 1 - 30) $59,200 (years 1 - 50)

Section 9

Stream gauging

The Caribbean Meteorological Institute (CMI) desires to accumulate stream-gauging data as part of a Caribbean-wide hydrometeorological data bank. Initial emphasis is on collection of stream and river flow data for the planning and design of potential hydroelectric powerplants in the eastern area of Dominica. The initial step is to select six stream-gauging sites, which are expected to provide information useful for siting and determination of electric power generation capabilities. Criteria considered in gauge-site selection are (1) dispersion of gauge sites to collect information representative of streamflows of the eastern/upland, central, and northern parts of the island and (2) correlation of streamflow patterns as related to rainfall patterns.

Sites considered

A series of field trips were made to locate suitable stream-gauging sites. The criteria were (1) a river location affording a stable and measurable cross section, (2) accessibility for daily reading (important for nonrecording gauges), and (3) sites where an early accumulation of data would be valuable for project planning. The following sites were considered:

1. Demitrie River at Penville
2. Layou River at Bells
3. Fond Eigues River at Fond Melle
4. Confluence of Raymondstone and McLaughlin Rivers
5. Saint Sauveur River at Saint Sauveur
6. Rosalie River at Rosalie
7. Browns River near Newfoundland
8. O'Hara River at road crossing
9. Riviere Cirique at road crossing
10. Stuarts River at Gueule Lion
11. Confluence of the Taberi and Ouagameri rivers at road crossing
12. Sarisari River at La Plaine
13. River Blanche at Delices
14. La Riviere Nyson at Petite Savane
15. Savane River at road crossing
16. Malabuka River at Bagatelle

Sites listed in table 19 were selected according to the criteria indicated.

Table 19
Gauging sites selected

Number	River	Drainage Area	Gradient	Cross Sections	Remarks
1	Demitrie	small	high	weir	--
4	Raymond-stone	large	low	current meter	--
8	O'Hara	small	medium	current meter	--
13	Blanche	large	high	current meter	Channel improvements required
14	Nyson	small	high	current meter	Channel improvements required
16	Malabuka	small	medium	weir	

Correlation between flow values and rainfall in the related catchment is useful for determining groundwater storage, time days between precipitation, and return flows and for predicting stream and river flows. Expansion of rain gauge installations is planned for this purpose.

Stream-gauging equipment

While in Dominica, the NRECA team became aware of the existence of unused stream-gauging and rain-gauging equipment presently under the care of the British Development Division in the Caribbean (BDDC). The gauges (two Leupold-Stevens, Type 4 Model 71 strip-chart river-stage units) were inspected and found to be in good condition with an ample supply of strip-chart paper. This equipment could be useful in the proposed CDB-sponsored stream-gauging effort or in the broader effort by CMI to work with the Dominican government in strengthening the island's meteorological and hydrological measurement activities. The team recommends that CMI or the government evaluate the usefulness of the equipment, and ascertain under what conditions BDDC might transfer the equipment to the government. BDDC's address is: Carlisle House, P.O. Box 167, Bridgetown, Barbados (Tel. 62190)

Section 10

Institutional issues

The establishment of sound institutional arrangements is essential to the success of a small hydro-based rural electrification program. Unfortunately, the scope of work and limited time available to the NRECA team did not permit it to deal directly with the institutional issues. However, some general observations can be made.

Rural electrification strategy for the east coast

Feasibility of separate small hydro installations. On strictly commercial grounds, the development of individual small hydro units in separate east coast communities does not appear to be a viable rural electrification strategy. However, the NRECA assessments were done at sites that appear technically and financially less desirable than sites currently being evaluated by Appropriate Technology International (ATI) (in La Plaine) and Canadian Energy Development Systems International (CEDSI) (in Delices and Castle Bruce). Furthermore, indirect and long-range economic and social benefits may well justify the investments from the government's standpoint. The government of Dominica, in establishing a strategy for rural electrification along the entire east coast, must consider the assessments of CEDSI and ATI as well as NRECA.

Responsibility for east coast electrification

Currently, DOMLEC has the exclusive right to generate and distribute electricity throughout the island. However, due to the requirement to operate profitably, together with the financial burden imposed by the havoc wrought by Hurricane David, DOMLEC has no plans to expand beyond the limits of the existing central electric grid. The costs of extending the grid, according to DOMLEC, are too great in comparison with projected revenues. Thus, although DOMLEC is legally the only institution that can electrify the east coast, it has no plans to do so.

The government has announced plans to obtain a controlling interest in DOMLEC by the end of 1981. Assuming that this takes place, several alternative strategies are--

The government negotiates with DOMLEC to abolish or modify the utility's exclusive right to generate and sell electricity on the east coast, thereby opening the way for alternative institutional arrangements.

The government and DOMLEC agree that the utility, with subsidized funds provided through the government, electrify the east coast.

The government compels DOMLEC to electrify the east coast, spreading the cost among all Dominican consumers. In effect, west coast consumers would subsidize east coast consumers.

It may be possible, for example, to link several communities to one or more slightly larger small hydro sites, such as at La Plaine or Delices, in effect creating an independent, hydro-based east coast grid. The LaPlaine and Delices sites are, perhaps large enough to justify the initial construction costs, particularly since the linkage to several communities could provide a greater initial load factor. Additional small hydro sites could be added later to keep pace with demand. A favorable factor supporting this plan is the current small hydro project in La Plaine. This 135-kW unit planned for the Sarisari River is scheduled for grant-funding by ATI.

It is likely that excess electricity will be available, at least initially, from the La Plaine site. The village council, in theory, may be interested in selling this electricity to neighboring towns, particularly Morne aux Fregate, Morne Jaune, and Riviere Ciriques to the north and Boetica and Delices to the south. For an additional cost in transmission lines only, these villages could be electrified.

The challenge to the government will create an institutional structure that links government, village councils, and, if necessary, DOMLEC, in matters of ownership and operation of the system.

Community role

Other developing countries have adopted or are experimenting with different levels of delegated responsibility for rural electrification, whereby the local or village administration places--

Heavy reliance on the electric utility and is responsible only for local billing and reporting on consumer complaints or requests for service.

Medium reliance on the utility and takes on additional responsibilities such as promoting service, identifies new areas to be served, and plans with local inhabitants to extend service to them.

Low reliance on the utility (as with a cooperative arrangement) and assumes many of the financial, technical, and administrative responsibilities.

The appropriateness of the selected arrangement in these cases in Dominica will depend on many factors.

The role of the local community is an important variable affecting small hydro development. Due to the NRECA team's brief stay in Dominica, this issue cannot be fully addressed here.

Rural Dominica has a long tradition of village council government, clubs, voluntary organizations, and cooperatives at the local community level. Rural citizens still rely on one another for exchange labor--coup de main--and various types of communal cooperation. We observed or learned of various "self-help" projects sponsored jointly by local communities, the local government and community development office, and outside sources of financing. These efforts have successfully built upon local cooperative traditions.

The most effective efforts are often short-term projects born to obtain specific ends, (the boxing plant in La Plaine and the school in Penville are cases in point). Structural cooperatives often fail. They are too long-term and are often organized from the top down without adequately taking into account the needs, differences, and relationships among members. Whatever the long-term institutional structure, we suggest that outside agencies work through the village councils in the construction phase, and at least to a limited extent, in the maintenance and operation phase. Specific suggestions relating to community involvement include--

(1) Involve communities from the beginning in site selection, planning, and development. Owing to logistical problems, the team was able to do this only in Petite Savanne and to a lesser extent, in Penville and Bagatelle. Community involvement has several potential benefits: improving technical siting considerations; strengthening community organization and social cohesion; resolving local land-use issues relating to water rights, penstock routes, etc; increasing the number of households utilizing electricity services; obtaining unskilled voluntary labor for construction; and improving maintenance and repair functions.

(2) Fit small hydro development into the existing pattern of "occupational multiplicity." East coast Dominican society, like other poor Caribbean rural areas, has a tradition of combining small-scale, own-account farming with periodic or part-time wage labor or small business/cottage industry. Two specific strategies for mini-hydro development stand out--

(a) Hire local labor for construction. Small hydro construction could lend itself to integration into Dominican rural work schedules. It would provide additional income to the island's poorest region and possibly bring into the labor force those, particularly women, who currently cannot or will not work because of home and child care duties. Through consultation with the village councils, the project could identify periods of slack labor demand when labor could be most readily obtained. Our conversations indicate that seasonal farm demand does not

fluctuate sharply. Some peak comes in April-June and October-November, before the rains, as farmers prepare the soil for planting of yams, cassava, and other seasonal vegetables. Primary crops such as dasheen, tannier, and bananas are harvested all year round.

(b)Train and hire local people for routine maintenance and repair functions. On the east coast, as in all the island, employment opportunities are severely limited, yet there are people with marketable skills who want to work, who are forced to emigrate, take jobs outside their field, or remain idle. It is possible to train local people in routine SDH maintenance. In the event of problems, the turbines will shut off automatically requiring someone with more technical skills to repair the equipment and restart the turbine. Trained personnel should be available in Dominica to perform this function. The Dupigny Technical Training College in Roseau reportedly graduates some 20 students yearly, some of whom have relevant electrical and mechanical skills. Many of these are unemployed or have emigrated, suggesting the existence of a pool from which to hire and retain skilled personnel. In spite of the mini-hydro sites' relative isolation, distances are small in Dominica and one or two technicians working with the communities involved could easily maintain a large number of installations. An alternative institutional arrangement might be to contract such work to the island's electricity utility.

Conclusions and recommendations

Policy. The government energy policy is not well articulated at present. To integrate the information currently being developed by public agencies and consultants and to mesh energy-related plans with investment sponsored by other agencies, the government should establish an electrification coordination working group. The group should include representatives of the Prime Minister's Office; Planning Unit; Ministry of Public Works, Communications, and Tourism; Central Water Authority; DOMLEC; and the Ministry of Home Affairs' Department of Local Government and Community Development; and interested units of the Ministry of Agriculture. Each interested agency should assign responsibility for electrification policy to one individual within its ranks.

Local organization. At present, the greatest amount of organizational work has taken place in the La Plaine area. Here, the village council is making plans to build and manage a small hydro site on the Sarisari River, with technical, organization, and limited financial assistance from Appropriate Technology International. The government should support this effort with the expectation that the institutional lessons learned will contribute to the extension of electricity to neighboring areas on the east coast.

Centralized Organization. The government has not devoted sufficient attention to the institutional arrangements necessary

for rural electrification on the east coast. These arrangements are a key element in any rural electrification strategy and will contribute to determining the structure of financing of rural electrification.

Taking advantage of ATI grant-funding and technical assistance at La Plaine, the government could seek additional soft-loan monies from its own Agricultural and Industrial Development Bank and perhaps the CDB which, blended together, would contain a significant grant element. This financing, applied to LaPlaine and extended to support the incremental east coast electrification strategy outlined above, could provide a financially viable alternative to individual village mini-hydro installations.

Village councils, with government assistance, might assume ownership and management responsibility. DOMLEC could be retained for needed technical assistance. Despite the generally mixed success of cooperatives in Dominica, a rural electric cooperative arrangement might be appropriate but should be attempted only after sustained discussions with the local government and community development field staff and village councils and after appropriate feasibility evaluations have been carried out.

Alternatively, reliance might be placed on DOMLEC, possibly under government contract and subsidy, to work with the village council and with one local non-DOMLEC employee to provide local billing, customer service, and maintenance.

Section 11

Findings and recommendations

Summary of findings

The NRECA team carried out preliminary technical surveys at 12 potential hydroelectric sites in Dominica. It determined four of these--at Petite Savane, Bagatelle, Rosalie, and Penville--to be possible SDH sites and calculated preliminary cost and benefit figures. The team determined one site (Layou River at Bells) to be appropriate for grid-connected hydroelectric generation. It analyzed another site--at the Antrim waterworks near Roseau--and calculated that retrofitting the existing water supply system to accommodate hydroelectric generation was not economically viable under present conditions. The team also selected six sites for the placement of stream-gauging equipment.

East coast SDH sites

Findings: Small hydro is technically feasible at the east coast sites visited. Although perhaps economically impractical on a short-term basis, the government may want to develop these sites for sociopolitical and indirect or long-term economic reasons, absorbing the immediate costs and in effect subsidizing initial rural electrification in the area. SDH development as part of an integrated rural development program would minimize this subsidy and lead to the most immediate benefits. SDH's financial feasibility would be greatly enhanced if combined with the reconstruction of village water supply systems in Bagatelle and Petite Savane.

Recommendations:

If it desires to proceed with east coast electrification, the government should first determine which of the three alternatives--extension of the grid, small diesel generators, or SDH--is most cost-effective.

To minimize rural electrification subsidies, the government should target areas of planned electrification with productive investments (housing, social services, and industry), thus making electrification part of an integrated rural development project.

Layou River/Bells Site

(a) Findings: The Layou River at Bells has a potential hydroelectric capacity of 400 kW, far in excess of the power requirements of the surrounding community. The high costs of developing this site could be justified only if the electricity generated were delivered into the central grid system.

(b) Recommendations:

The Layou River/Bells site should be developed only as part of an expansion of the existing grid system.

The government or DOMLEC should refine the approximate costs and benefits of development of the Layou River/Bells site in order to determine its priority relative to alternative investments.

Antrim

(a) Findings: The NRECA team analyzed the Antrim proposal with the idea of demonstrating the feasibility of combining water supply and grid-connected electricity generation. The analysis shows that the concept is technically feasible. However, owing to design features of the existing water supply system (particularly the pipeline from the intake to the settling tank) and the characteristics of DOMLEC's generating capacity and load curve, modification of the present water supply system is not financially viable. Simply put, hydroelectricity from the present Antrim facility would be too expensive to provide peak system capacity.

It is likely that water system demand will exceed the existing pipeline capacity within the next 10 years, at which time a new or supplementary pipeline would be necessary. The new pipeline could be designed to accommodate a turbine-generator installation that would permit optimum operation of both water supply and power systems.

(b) Recommendations:

Installation of hydroelectric capacity at Antrim should not be undertaken at the present time.

The government and the Central Water Authority should determine existing and projected water demand of the Roseau area over the next 10 years in order to establish when construction of a second pipeline will be required.

If concrete plans are made to install a second pipeline at the Antrim facility, the government should authorize the appropriate entity to study the feasibility of integrating hydroelectric generation into the expanded water supply facility.

Stream gauging

(a) Findings: The NRECA team, in close cooperation with a representative of CMI, found six sites suitable for stream-gauging. Installation of these gauges would be part of an effort to provide hydrological data, facilitating SDH development and, over the long term, strengthening Dominican hydrological and meteorological data gathering and analysis capabilities.

(b)Recommendations:

In cooperation with designated government personnel, CDB should finance and CMI install, stream gauging equipment at sites on the following rivers:

Demitrie River (Penville)
Raymondstone River (above Castle Bruce)
O'Hara River (Rosalie)
Riviere Blanche (Delices)
Riviere Nyson (Petite Savane)
Malabuka River (Bagatelle).

Installation of this equipment should be done by spring 1982 in order to begin gathering dry season streamflow data.

Institutional issues

Technical factors alone will not determine the future development of SDH, in particular, or east coast electrification, in general. Other broad and interrelated institutional issues will play a large role in defining the nature and pace of electrification in the region. Unfortunately, the scope of work and limited time available to the NRECA team did not permit it to deal directly and fully with these issues. However, some tentative findings, remaining issues, and recommendations are presented below.

(a) Findings:

The government has not determined which institution will implement SDH or other electrification on the east coast.

DOMLEC presently holds the exclusive right to generate and distribute electricity in Dominica.

At present, DOMLEC is not financially capable of, nor interested in, developing electric systems on the east coast.

At present, several entities (CEDSI, ATI, Ministry of Public Works, village councils, DOMLEC) are potentially interested in participating in east coast electrification.

The government is preoccupied by the issue of financing.

SDH on the east coast will require a subsidy.

Village councils and the local populace are very interested in having their areas electrified.

Significant potential exists for local involvement (for example, donated and paid construction labor, management, and maintenance).

(b) Issues: Remaining issues include--

What will be the source(s) of foreign exchange and local financing and the extent of subsidies that the government could justify?

Which entities would be responsible for planning and executing east coast electrification? Would electrification take place through one or several subsystems?

What is the present and potential competence (trainability) of local people to perform lesser-skilled construction work and later maintain SDH and distribution subsystems?

What would be the role of DOMLEC in training a cadre of operation and maintenance personnel?

(c) Recommendations: The NRECA team presents the following suggestions for the government of Dominica in relation to the institutional questions raised above:

The government should consider revoking or modifying DOMLEC's current exclusive right to market electricity on the island. This would allow for village council, rural electric cooperative, or alternative institutional arrangements as locally appropriate.

If DOMLEC continues to be unable or unwilling to electrify the east coast in the near future, the government should utilize local resources for planning, constructing, and maintaining SDH or other east coast electrification infrastructure. (The NRECA team assumes that the government will prefer to work through the existing village council structure.) Local labor should be hired, or otherwise contracted, for construction, and local people should be trained and hired for routine maintenance, billing, repair, and other functions.

The government should encourage and materially support, as much as possible, the current ATI-assisted efforts by the La Plaine village council to develop a mini-hydro site on the Sarisari River.

Should the government choose to implement an SDH strategy, it should consider linking several communities to one or more of the larger SDH sites, such as at La Plaine or Delices, in effect creating one or several independent, hydro-based east coast grids. As demand increases, additional hydro sites could be developed.

In accord with the above, the government should consider forming an east coast quasi-utility, organized under concessional construction cost financing with some degree of cooperative or volunteer work-input to basic operation, maintenance, and administration. Consistent with this approach, DOMLEC might be

assigned responsibility for top-level technical operation and maintenance. Grid interconnection should be explicitly considered in siting and sizing the SDH projects and in designing their initial and projected distribution systems. Eventually, east coast SDH generation and DOMLEC generation could be pooled through a primary distribution voltage connection. Net generation into or out of the east coast could be purchased or sold at agreed tariffs.

Appendix A

Scope of work--Dominica (approved by USAID)

It is proposed that NRECA send a mini-hydro team to Dominica to perform prefeasibility studies of candidate sites with potential for providing decentralized rural electrification. The team will identify several possible sites, select at least six (6) for additional investigation, and conduct on-site studies at these locations. Additionally, at least one site will be studied for the feasibility of providing grid interconnected or mechanical power production from mini-hydropower installations. All sites will be evaluated at a "reconnaissance" level of detail to identify those sites which promise the greatest benefits for the lowest cost. It is understood that separate and additional in-depth analyses will have to be performed at specific sites before accurate cost estimates can be made.

The NRECA team will consist of four members who will work with one or two Dominican counterparts. These counterparts will be identified by the Ministry of Communications, Works, and Tourism. The team will consist of a civil engineer, an Electro-Mechanical Engineer, a Socio-Economic Advisor, and an Institutional Advisor. One member will be designated as the Team Leader.

The team's activities will consist of:

	Estimate duration (days)
Review activity background documents	2
Travel to Washington for NRECA, AID briefing	1
Travel to Barbados for AID CDB, CMI briefing	1
Travel to Dominica	1
Collect data	2
Identify candidates study sites	2
On-site field measurements	10
Draft report--debrief Government of Dominica	4
Travel to Washington--debrief NRECA and AID	1
Finalize report	5

The details of the report are further described in the following position descriptions. In addition to preparing the final report, the team members are also tasked with providing hands-on training to their Dominican counterparts in the course of the assessments.

The Government of Dominica will contribute in this effort by providing:

Counterpart individuals during the study period.

Transportation for the team--this will be especially important for the field work.

Identify local villagers to act as guides for the field work.

Providing topographic maps and hydrologic data for the team's use.

Civil Engineer

The Civil Engineer will have the responsibility for recommending the appropriate civil works, hydraulic lay-out and stream gauging locations. During the identification phase of the assignment he/she will (1) identify catchment basins with reliable year-round flow; (2) identify possible locations for mini-hydro schemes; and (3) develop criteria for candidate sites. During the field phase of the assignment the Civil Engineer will (1) visit sites to lay-out diversion structures, headraces, and power houses; (2) make actual head measurements; (3) estimate flow headrace length, penstock length; and (4) assess potential environmental and geological problems.

For the report, the Civil Engineer will estimate the flow duration at each site studied, qualify the reliability of the data, estimate the cost of the civil features, and provide a general site description. In addition, he/she is to recommend locations for placing six (6) stream-gauging instruments in the eastern nonelectrified area of the island for the purpose of collecting stream flow data. This recommendation will be provided for the stream-gauging project proposed by the CDB, and should be coordinated with the Dominican Forestry Department and the Caribbean Meteorological Institute.

Electro-Mechanical Engineer

The Electrical-Mechanical Engineer will have the responsibility for recommending the appropriate turbine, generator, and electrical distribution features, and estimating their cost. During the identification phase of the assignment, he/she will (1) develop criteria for extending the existing grid vs. installing small decentralized hydropower; (2) develop criteria for a maximum distance from the powerhouse to the load center; (3) merge the above criteria with sites identified by the Civil Engineer to locate potential sites. During the field work phase

he/she will (1) investigate the path for distribution lines from the powerhouse to the load center, and (2) assist the Civil Engineer and the Social Analyst with the electrical aspects of their work.

The Electro-Mechanical engineer will prepare those portions of the final report with the turbine, generator, distribution schemes and their cost.

Institutional Advisor*

The Institutional Advisor will analyze the existing institutional, legal, policy, and future relations between the Ministry of Communications, Works, and Tourism, Ministry of Housing, Dominican Electric Service Ltd., (DES), Public Service Commission, Central Water Authority (CWA), and other donor agencies with respect to mini-hydro development. Within this framework, the advisor is to investigate possible relationships for government ownership, private ownership, or local community ownership of small decentralized energy installations.

From the above investigation, the advisor is to recommend appropriate management/ownership arrangements for sites similar to the ATI installation at La Plaine, installations at government facilities, and private installations that are to be interconnected with the electrical grid. This recommendation should fit into an overall energy plan for resource development in Dominica. It will include responsibilities of the various Ministries, DES, and donor agencies.

In addition to the above analysis, the advisor will review completed studies related to mini-hydropower in Dominica and recommend a government policy for mini-hydro development and an implementation plan for carrying out this development.

Socio-Economic Advisor

The Socio-Economic Advisor will be responsible for the social, economic, and financial analysis of the mini-hydro prefeasibility studies. This would include collecting background information on the social structure in Dominica, and on-site observations of electrified and nonelectrified rural communities in Dominica. He/she is to identify possible uses of electricity in rural areas, their social and economic impacts, and other secondary impacts.

From the above investigation, the Advisor will estimate the initial electrical demand and projected electrical growth rates for the target villages.

*This position was eliminated prior to departure of the team for Dominica.

Dominica stream-gauging project terms of reference for consultants (approved by CDB)

Introduction

It is proposed to establish a hydrological and stream gauging data collection network in the Eastern District on the island of Dominica. This network will comprise six (6) stream-gauging stations, and is intended to be the first phase of an islandwide network to be ultimately established. The siting of the initial six (6) station network will be optimized with regard to gathering data for hydropower production in small decentralized systems in this area of Dominica, and is in response to requests from the Government of Dominica for assistance in this area.

The object of this study will be to make recommendations on the siting of the six (6) gauging stations to be set up and calibrated by the Caribbean Meteorological Institute (CMI), and such recommendations shall, without limit, take account of the following factors:

Government priorities in electrifying the Eastern District;

Preliminary assessment of local power market;

Preliminary selection of possible power transmission routes;

Preliminary selection of penstock routes, powerhouse sites, and location of impounding headworks.

In the performance of this assignment, the consultant shall therefore undertake the following:

(i) Preliminary site survey. Carry out a preliminary survey of the Eastern District of Dominica to make an overall survey of the various catchment areas and their run-off between the Villages of Marigot and Delices. The object of the survey shall be to determine the possible sites for future small decentralized power production.

(ii) Consult with Government. Consult with Government representatives in:

Ministry of Communications, Works & Tourism;
National Planning Organization; and
Forestry Division

with a view to determining Government priorities in the electrification of the Eastern District, and to obtain data on rainfall, topography, etc.

(iii) Preliminary power market estimate. Carry out a preliminary estimate of the market for power produced from the above sites with a view to determining which of the sites appear capable of supporting commercially viable power production projects.

(iv) Preliminary selection of penstock routes, etc. Make preliminary selections of probable penstock routes and powerhouse sites, etc., with a view to establishing likely construction costs.

(v) Preliminary selection of power transmission routes. Make preliminary selections of probable power transmission routes from powerhouse sites to village load centres with a view to estimating construction costs.

(vi) Socio-economic survey & ranking of scheme. Based on the above preliminary examinations, carry out a brief preliminary socio-economic cost/benefit analysis of each of the schemes considered and by so doing, produce a ranking of the schemes and identify the six (6) best streams and the locations on them for establishing the gauging stations. The consultants of multi-purpose schemes for providing power to agro-industrial or other projects in addition to domestic loads.

Notwithstanding anything contained in the foregoing, the consultants shall be at liberty to suggest alterations to these Terms of Reference, providing that such alterations shall not vary the overall scope and intent of the study.

Scope of work

The consultants shall visit Dominica for the purpose of carrying out the work described in the above Terms of Reference, and shall, at the conclusion of the visit, produce a report which will contain recommendations for the siting of the six (6) stream gauging stations.

Appendix B.

Letter to NRECA from the Office of the Prime Minister

OFFICE OF THE PRIME MINISTER
ECONOMIC DEVELOPMENT UNIT

Telegrams : External, Dominica.
Telex 413 EXT. DO
Tel.. 1461
Reference. 2/03-15-01

GOVERNMENT HEADQUARTERS.
ROSEAU.
COMMONWEALTH OF DOMINICA.
WEST INDIES.

Mr. Walter Lawrence, NRECA.

13th November, 1981

Gentlemen,

This communication confirms your meeting with the Hon. Minister of Communications, Works & Tourism on the subject matter.

The Ministry has identified, as listed below, four (4) areas for your specific attention, separate from the three (3) sites being examined by Wason Consultants Ltd in association with CEDSI and CEP.

USAID / NRECA Allocated Areas.

- Penville / Demitrie R.
- Atkinson
- Rosalie / Grand Fond
- Petite Savanne

In addition the Ministry of Communications, Works & Tourism requests that you determine through discussions with Wason Consultants Ltd CEDSI / CEP which of their project streams/rivers will require your services under your project for hydrological and stream gauging data collection.

CEP Address:
Consulting Engineers Partnership
(Mr. I.W. Gregoire)
Jean Baptist House
Old Street, ROSEAU

Telephone No: 3208

Yours sincerely,

C.A. HARRIS

c.c: Hon. Minister/Communications, Works & Tourism
P.S./Communications Works & Tourism
Chief Forestry Officer
Chief Technical Officer/Communications, Works & Tourism.

CAH/se.

Appendix C

People contacted in Dominica, Barbados, and Washington, D.C.

NRECA DOMINICA Small-Scale Hydro Team Visit, November 3-25, 1981

Dominica

Richard Acquaah-Harrison, physical planning advisor, Prime Minister's Office

Herman Adams, country team leader, Caribbean Agricultural Research and Development Institute (CARDI)

Cornelius Antoine, member, Petite Savane Village Council

Isaac Baptiste, physical planner, Prime Minister's Office

Conrad Cyrus, Rosalie Estate, and representative to National Assembly of Dominica

Athena Darraux, member, Petite Savane Village Council

Philipe Diereck, member, French technical mission

Henry Dyer, minister of public works, communications, and tourism

Frank Farnum, hydrometerorologist, Caribbean Meteorological Institute

Centville Felix, road superintendant, Rosalie/Grand Fond, Ministry of Public Works, Communication, and Tourism

John Fountain, assistant district development officer, Local Government and community Development Office, Ministry of Home Affairs

Jerry Glenn, volunteer, Partnership for Productivity

Felix Gregoire, assistant director, Department of Forestry

J. C. W. Gregoire, Consulting Engineers Partnership, Ltd

Miss Harriett, village council clerk, Bagatelle/Fond St. Jean/Pointe Caribe

Cary Harris, Planning Unit, Prime Minister's Office

Glen Ichikawa, engineer, Canadian Energy Development Systems International

Thomas Isadore, director, Central Water Authority

Frazer Jones, former chief engineer, Central Water Authority

Francis Joseph, district development officer, Local Government and Community Development Office, Ministry of Home Affairs

Randall Laronde, appropriate technology specialist, CARAIBES Alternative Energy Ltd

Alfred Levy, assistant permanent secretary, Ministry of Home Affairs

Christopher Maximea, director, Forestry Department

Oswald McAlmont, generation engineer, Dominica Electric Service (DOMLEC)

Terry Mirabito, consultant, Pan-American Health Organization

Michael Murphy, director, Statistics Department, Ministry of Finance

Maximea Ponponne, member, Petite Savane Village Council

Steve Prest, engineer, Curran and Associates

Greg Robbins, Caribbean Agricultural Research and Development Institute (CARDI).

Andrew Royer, organic farmer, Giraudel, Dominica

Augustin Scotland, director, Community Development, Ministry of Home Affairs

Cecil Shilingford, manager, Dominica Electric Service (DOMLEC)

Mr. Shillingford, chief, Agricultural Statistics, Botanical Gardens

Trotter Stoute, president, Petite Savane Village Council

Mr. Tonge, forest warden, Dleau Gommier National Forest Reserve, Department of Forestry

Mr. Vidal, forestry officer, Department of Forestry

Burleigh Williams, forestry officer, Calabishie, Department of Forestry

Washington, D.C.

Jim Cotter, Inter-American Foundation

James Finucane, Appropriate Technology International

Robert Maquire, Inter-American Foundation

Robert Mashek, Inter-American Foundation

Ed Towle, Island Resources Foundation

Barbados

Alex Sundermann, United States Agency for International Development

Basic Sutherland, Caribbean Development Bank

We would also like to thank:

village councils and/or residents of the Communities of Bagatelle/Pond St. Jean, Bells, Grand Fond, Riviere Ciriques, Penville, Petite Savane, and Rosalie

district development officers and community development assistants, Local Government and Community Development Office, Ministry of Home Affairs

Appendix D

Energy prices in Dominica

(November 1981)

Fuel	Price (EC$)
Kerosene	4.13/imperial gallon (wholesale) 4.20/imperial gallon (retail)
Diesel	4.36/imperial gallon (wholesale) 4.57/imperial gallon (retail)
Gasoline	6.01/gallon (retail)
Propane	24.00/50 lb. cylinder

Appendix E

Assumptions for economic analysis

All prices in 1982 US$
Time period: 30 years
Discount factor: 10%

Initial values

50% of area households initially served.

Average initial household electricity consumption is 30 kWh/month at US $0.1314/kWh equaling yearly consumption of 360 kWh costing US $48.

Average pre-project yearly consumption of kerosene for household lighting (all households) and refrigeration (10% of households): US $96.

Average initial net consumer savings from use of electricity: US $48.

Escalators

15% annual growth in average community electricity consumption

10% annual growth in value of displaced kerosene consumption

4% annual growth in real costs of diesel

60% maximum load factor.