CARIBBEAN RESEARCH INSTITUTE

WATER POLLUTION REPORT No. 13

DECENTRALIZED WATER REUSE SYSTEMS IN A WATER SCARCE ENVIRONMENT: THE TOURIST INDUSTRY IN ST. THOMAS, VIRGIN ISLANDS

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GOVERNMENT OF THE VIRGIN ISLANDS

DEPARTMENT OF HEALTH, DIVISION OF ENVIRONMENTAL HEALTH

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CONTRACTED BY

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May, 1971

FORWARD

This report is based on the work of three undergraduate students from Clark University, Worchester, Massachusetts, who operated under the partial aegis of an agreement between the Caribbean Research Institute of the College of the Virgin Islands and the Department of Health, Division of Environmental Health, of the Government of the U.S. Virgin Islands. Partial funding was also contributed by the Graduate School of Geography of Clark University and the U.S. Office of Water Resources Research. The support from these various sources is gratefully acknowledged.

This report continues a relationship between Clark University and the U.S. Virgin Islands directed at research on environmental problems. Previous studies have been conducted by Martyn J. Bowden, Associate Professor of Geography, and John T. Reynolds, Professor of Microbiology, both of Clark University. The present project is a continuation of an effort begun in 1970 dealing with water reclamation prospects in St. Thomas and carried over during the independent study period at Clark University in January of 1971. The specific intent of the various projects is to collect and analyze a variety of information concerning environmental problems which can be of direct use in planning programs in the Virgin Islands. It also, of course, is an important application of concepts and skills developed in pedagogy to the real world.

The present project was directed and coordinated by Roger E. Kasperson, Associate Professor of Government and Geography at Clark University. Its objective was to gather basic data on water consumption and sewage disposal facilities at major tourist establishments in St. Thomas. These data were analyzed with the specific intent of providing some rudimentary indications of the feasibility of water reuse systems outside the limits of Charlotte Amalie.

The author wishes to express his gratitude to John Reynolds and Dan Dworkin for reviewing the manuscript and suggesting a number of useful changes, as well as acknowledge the helpful critical comments of Pedrito Francois, Director of Environmental Health, and Neva Carlson, Research Assistant, at the Caribbean Research Institute. The study is also indebted to Robert vanEepoel, Research Associate and Project Director of the Caribbean Research Institute, who encouraged us to do the research and provided assistance in the field work.

CONTENTS

I. INTRODUCTION

There has been much recent discussion concerning the need for technologies to enlarge the range of choice in water supply for areas suffering from either limited surface and ground water supplies and/or burgeoning domestic, industrial or commercial demand. In most insular and maritime environments the search for enlarged supply generally involves consideration of desalinization Such has been the case in St. Thomas in the U.S. Virgin Islands where three seawater desalinization plants have been constructed during the last decade to meet the municipal needs of the Charlotte Amalie system. These plants are all of the flash-distillation type and have capacities of .275, 1.0 and 2.5 mgd respectively. Since many outlying areas in the island also draw upon the municipal system to augment their own supply, in effect desalinization is serving many of the large volume users on the island. Thus far, this means of augmentation has met the rapid population and touristic growth in the city of Charlotte Amalie; it is a much less satisfactory supply solution, however, for the rest of the island.

The search for means to augment water supply has included some attention to alternative systems. Charlotte Amalie has long employed a dual water system in which salt water has been used for flushing and waste disposal. In 1968, Engineering-Science, Inc. completed a water reclamation study for the Virgin Islands which included proposals for reclamation and reuse on both St. Thomas and St. Croix. Hotels and resorts have, either on a permanent basis or during droughts only, urged their guests to restrict their comsumption of water. Some have even tried to add incentives to compliance by suggesting "Shower with a Friend." Some employ water-saving devices, such as automatic shut-off showers and faucets, other systematically monitor their system for leakages.

There has apparently been little systematic study, however, of the growth of high volume users in the tourist industry scattered throughout the island in areas remote from the production of desalinized water. The rapid appearance of this network of commercial establishments in an island with limited and uncertain water resources and a high quality physical environment directly connected to its economic well-being raises difficult problems both for efficient water supply and waste disposal. In such a situation, there is a unique opportunity for a decentralized water reuse system which employs package treatment plants and utilizes the effluent to reduce the high costs of water supply. Simultaneously, the reduction of wastes disposed directly to adjoining maritime waters helps preserve the aesthetic properties of a beautiful physical environment.

This study has as its objective, therefore, to survey the means by which tourist establishments are presently dealing with their twin problems of water supply and sewage disposal and to assess in a very preliminary way the feasibility of water reclamation and reuse systems. The scope of the study is limited, therefore, to

private touristic establishments and does not include experimentation by residential subdivisions, other residential estates, or industrial firms. To gather data, a stratified sample of sites was selected so as to include the largest tourist establishments as well as a number of smaller resorts. A number of establishments within the Charlotte Amalie system were interviewed as control observations with which to compare our sites outside that system. Several sample establishments refused to cooperate; a number of others showed obvious disinterest. The final eighteen establishments studied are shown on Map. 1. The records kept by each vary widely, however, so that the evidence for the study is still fragmentary and incomplete at best. The interview utilized is included as an appendix, and was given to owners, managers, or maintenance engineers.

II. A DEFINITION OF TERMS

The literature on water reuse is plagued by a plethora of terms and meanings. To clarify the present discussion, a number of preliminary definitions are proposed:

Package Treatment Plant - a wastewater treatment plant ranging in capacity from 600 gpd to 140,000 gpd that utilizes long-term aeration, final sedimentation and chlorination and which is designed to serve resort complexes, shopping centers, apartment buildings, factories, small subdivisions, and even private homes.

Reclaimed Water - wastewater which has been treated with the specific intent of restoring its quality to a level where it may be utilized as a source for augmenting water supply.

Renovated Water - wastewater which has been treated to a level which restores its quality to that which prevailed prior to its use in the supply system under consideration. As used here, then, renovated water is a high quality subclass of reclaimed water.

Water Reuse - the use of reclaimed water.

III. THE WATER SUPPLY SITUATION IN ST. THOMAS

The climate of the Virgin Islands is, of course, a key factor in the tourist industry. Temperature averages 78°F. and generally ranges between 70° and 90°F. The mean rainfall is commonly set at 44.63 inches, but a recent study by Martyn Bowden has indicated that less than 42 inches is probably more accurate. In addition, his study indicates a long-term drying trend in the Virgin Islands as a whole.[3] There is much variability in seasonal and annual rainfall. Since most of the rainfall is convectional in type and average slope of the island great, the rate of runoff is also high. Droughts are common; Martyn Bowden indicates that St. Thomas has experienced a drought every year since 1934 according to the Palmer index.[4] Ground water is limited and does not constitute a source of significant supply except in some scattered interior areas. Since most tourist establishments locate on the shoreland perimeter of the island, surface waters are usually unavailable and whatever ground water is present tends to be brackish.

The traditional supply system on the island is a combination of rain barrels in residential slums, rain cisterns for most residential areas including the isolated single family dwellings scattered throughout the island, and catchments for institutions and settlement concentrations. It was in 1926 that small areas for rain catchment were first installed with a drain off into concrete storage tanks to supplement the roof water flow into house cisterns. By 1945 there were 440,000 square feet of paved catchment areas and a 3.5 million gallon storage capacity in the Charlotte Amalie supply system.[5] Cisterns, catchments, and rain barrels all reply upon rain water, however, so the island has since 1955 needed a supplemental supply to handle periods of drought as well as the rapid population, touristic growth, and per capita consumption increases in Charlotte Amalie over the last two decades. Water barged from Puerto Rico has filled this gap in the municipal water supply system and provided a buffer against rainfall uncertainty. The volume of barged water has reached extensive proportions; in fiscal year 1968, for example, 180 million gallons were barged from Puerto Rico. In recent years, however, the construction of the desalinization plants in Charlotte Amalie has replaced barged water as the major source for the municipal supply. The regular contract for water barging has now been terminated.

The development of the municipal supply has not, however, solved the problem for outlying establishments in St. Thomas. They have been forced to deal with the question of water supply individually, and a variety of adjustments has resulted. As Table 1 indicates, all of the establishments outside of the municipal system and all but one (Carib Beach) inside the system utilize cisterns for at least a portion of their supply. Not only does the cistern collect available rainwater, but the related impoundment facility also provides storage needed whatever the source of supply. Ground water is rarely a significant means of supply and where it is

employed the well water is generally used primarily for flushing purposes. Cisterns are relatively economical both to install and to maintain. The Virgin Islands Hilton indicated that their three cisterns of 50,000 gallons capacity cost approximately $15,000 each to install. Assuming a 20-year project life, an eight per cent discount rate, and an annual maintenance and operation expenditure of $700, this works out to about 5.3 cents per gallon per year for constructing and operating the cistern. Of course, that facility furnishes in any given year many gallons of water for each gallon of capacity depending upon the extent of rainfall and the total area of roof catchment.

Given the relative cheapness of installation, the low maintenance and operating costs, and the high quality of the product delivered, the extensive use of cisterns as the common denominator for water supply is an effective managerial adjustment. The scale of investment in cisterns is limited largely by the roof space available and influenced obviously by access to the municipal system. All the larger resort complexes - Pineapple Beach Club, Sapphire Bay Resort, Limetree Hotel and Beach Club, and Cowpet Bay Village - in our sample located at some distance from Charlotte Amalie have installed cistern capacities ranging from 750,000 to 1,205,000 gallons. Table 2 shows the overall pattern of cistern development at tourist establishments.

Cisterns are not in themselves, because of the variability of rainfall, adequate to ensure a dependable supply, however. As a result, individual enterpreneurs have looked to several means for augmenting supply; the purchase of water from trucking companies, desalinizing water from the sea, or utilizing either sea water or reclaimed waste water in a dual supply system. Restricting consumption is also a possibility, but most establishments have chosen to eschew this alternative.

Trucking companies for water have operated in St. Thomas since about 1954. The oldest of these, Trans-Inc. Water Company, owns three trucks, each of which can carry up to 10 tons (2500 gallons of water), and serves approximately 150 regular customers during dry years. The water companies obtain water from the municipal system at the standard price of $2.00 per 1,000 gallons. All charge the consumer a standard price determined by his location in the rate structure of the island (Map 2). Large volume consumers may be given a slightly reduced rate, especially if they obtain a regular contract with the trucker. The cost of water jumps astronomically as one leavesthe city limits; one hundred thousand gallons of water obtained from a municipal connection costs the buyer $200, whereas a consumer immediately outside the city limits must pay $1,400 for the same amount from a trucker. A buyer on the western end of the island, perhaps 45 minutes to an hour away from the city, must pay $2,000 for those same 40 truckloads of water.

The implication for large volume water-using establishments is clear; water becomes a very significant operating cost. Water purchases at the Indies House, a moderate size establishment of 32 units, run $1,900 a month during 100 per cent occupancy, even with cisterns and extensive reuse. The respondent at the Lime Tree termed water the highest operating expense for the establishment in the first three months of its operation. At the large Sapphire Bay Resort (580 guest capacity), the 1970 bill for water purchases was $60,000, and that with only about a 50 per cent occupancy rate for the year, with a salt water flushing system, and a water purchase rate reduced to $9.00 per 1,000 gallons.

The high cost of water in the non-municipal areas of the island is not, however, due to extravagant profits by the trucking companies. Rather, it arises from a system containing a single point of supply with very high transfer costs involved in distribution. Roads are generally poor and crowded along the precipitious slopes of St. Thomas, and the cost of acquiring the trucks, parts, and maintenance skills to keep a water trucking operation going in a Caribbean island is outrageously expensive. Anticipating substantial savings in the cost of water, the Pineapple Beach Club acquired its own water truck and bought directly from the municipal system at $2,00 per 1,000 gallons. Managers of the club estimate that they were able to reduce their total cost of water to $7.00 per 1,000 gallons, but this figure includes water from all sources and they may be under-estimating depreciation costs. Such an option is not, in any case, a viable alternative for smaller establishments.

The second major adjustment employed to deal with the supply problem is to reduce the volume of high cost water which must be purchased. One method is to restrict the volume of water consumed by guests. Since the consumption of guests was estimated in our interviews as ranging between 125 and 200 gpd compared with a mainland figure of about 70 gpd (excluding industrial use), there would appear to be ample opportunity for cutting costs. Yet, none of the 18 establishments interviewed presently imposed any water restrictions upon guests, despite the fact that 1970-71 was a dry year. The extent of action in this direction is to post signs politely asking guests to conserve water (and the Virgin Islands Hilton and Michele Motel have removed even this request), to install automatic shut-off showers and faucets, and to monitor and fix dripping faucets. The explanation for the lack of adjustments to reduce guest consumption is that tourists would not wish to pay the high price (ranging up to $70 per capita per day) for accomodations in the Virgin Islands and be told to restrict water.

A second means of reducing the cost of high quality water is to install a dual water supply system which will utilize a poorer quality water for such

lower order uses as flushing and lawn irrigation. This is by no means a recent innovation in St. Thomas for the city of Charlotte Amalie has long had a separate salt water system for exactly this purpose. Since salt water costs only 15¢ per ton (with a small charge for the connection) as compared with 50¢ for potable water, many inhabitants and merchants in the city have taken advantage of the savings possible. Drawing upon this precedent, resort complexes outside the municipal limits have also installed dual systems. Such systems have frequently been based upon salt water where the complex is adjacent to the sea. Generally salt water is pumped from the sea, used for flushing, treated, and returned to the ocean. In others, the fresh water effluent is treated and circulated through the secondary system for flushing and irrigation. There is still a third system which draws upon brackish water from wells for the lower quality water. The distribution of these dual systems is shown on Map 3.

IV. THE SEWAGE DISPOSAL SITUATION

Although not as severe as the water supply problem, sewage disposal also creates problems for local inhabitants and merchants. Even in Charlotte Amalie, the only municipal scale sewage disposal system on the island, raw sewage is inadequately collected and dumped into the adjacent harbor. The present facilities handle an average of 2 1/2 mgd and are badly overburdened. Approximately 70 per cent of dwellings now are connected to the municipal sewage system. A developmental plan is in the initial stages, however, for a primary treatment plant, interceptors, force mains, and pumping stations. Bids have already been taken on the treatment plant and interceptor and the municipal disposal situation should be improved over the next three to four years. There are no immediate plans for switching from the dual system to a completely fresh water system, because of the dramatic increase in water supply that would be required.

Outside of Charlotte Amalie, there are, according to a study conducted by John Reynolds, some 53 treatment plants in use.[6] Tutu presently has two package treatment plants, of which one operates at low efficiency and effectiveness. Ultimately there is thought of a central sewage system and treatment plant in Tutu, but there are no plans for the immediate future. The study by Engineering Science, Inc. suggested that Tutu could process its sewage for ground water recharge since it is one of the few areas where such a system would be possible.[7]

Tourist establishments outside Charlotte Amalie use both septic tanks and package treatment plants in sewage disposal. Reynolds estimates that there are at least 1250 septic tanks in use at various facilities in the rest of the island.[8] He also notes that terrain and soil characteristics create problems in installation and maintenance. The five tourist establishments surveyed in this study which use septic tanks confirm this generalization. Normal maintenance charges ran between $600 and $900 per year at the five sites, but did not include periodic major expenses.

Pelican Beach Club furnished the most complete data on septic tank costs. For its capacity of 44 guests, it built 14 septic tanks in 1961 at costs ranging from $1200 to $1400 for each tank. Its annual maintenance charge for the complex is $900. Assuming a 20-year project life and an eight per cent discount rate, this works out to be about $78 per guest per year for sewage disposal, assuming 100 per cent occupancy. Yet this figure seriously underestimates cost, for the management has experienced considerable problems with its septic tanks.

Six years after installation, it had to dig up all the lawns and replace all the drainage pipes and fields. Sapphire Bay abandoned their septic tank system and moved to large-scale package treatment after experiencing problems with their system. Although figures were not available on the costs to the Pelican Beach Club, they must have been very substantial. Over the experience of the past 10 years, then, an adjusted figures of about $95 per guest per year for sewage disposal, assuming 100 per cent occupancy, would appear to be more realistic for this establishment.

The situation for package treatment plants will be analyzed in the discussion of water reuse systems. First, it is necessary to summarize briefly the recent growth of tourism in St. Thomas and to analyze its impact upon water consumption.

V. THE GROWTH OF TOURISM AND ITS IMPACT UPON WATER CONSUMPTION

Tourism is presently the most important single industry in the Virgin Islands. Attracted by the climate, beaches, the largely unpolluted environment, and the $200 gift and one gallon of liquor duty-free allotment for visitors returning to the mainland and Puerto Rico, tourists visit St. Thomas in large numbers and spend sizeable sums shopping. The government of the Virgin Islands estimates that receipts from tourism have grown from $25.3 million in 1960 to $112.3 in 1969, a more than fourfold increase. Motor vehicle ownership has increased from 5,000 in 1960 to 18,000 in 1968. Over the same period, per capita income has risen from $950 to $2200 per year.[9] Since Pan American inaugurated flights to the islands in January, 1966 (followed by Trans Caribbean and Eastern in 1969), air traffic has grown from 339,665 passengers in 1966 to 566,586 in 1969. Preliminary figures for 1970 show some setback, however, reflecting the general economic decline and the lowering of North Atlantic air fares. There is also a marked seasonality to tourism in the Virgin Islands (Figure 1); in fact, several establishments close up entirely during the summer off-season.

Because of this growth of tourism (Table 3), the number of hotels and resorts in St. Thomas has increased markedly. In 1960, there were 36 hotels with a total of 841 rooms on the island. A decade later, these figures had increased to 64 and 1,924 respectively, for an average annual growth rate of 12.9 per cent. Although this rate is lower than the average annual increase of 18.6 per cent in air arrivals, it is only recently that St. Thomas has attracted overnight visitors on a large scale. The chronological development of tourist resorts included in this study is shown in Map 5. The Virgin Islands Tax Incentive Act which exempts qualifying hotels from real estate taxes for a 16 year period also encourages hotel building.

Table 4 provides a summary of the present size and projected growth of the tourist establishments included in this study. Particularly striking are the largest resort complexes, built in the last decade in outlying areas of the island, generally with adjacent beaches. Pineapple Beach Club, Sapphire Bay Resort, and Cowpet Bay Village all are examples. A number of these, as indicated in Table 4, are planning major expansion in the near future. Given the limitations outlined above in the water supply and sewage disposal situations, resort development has already had an impact upon investment and operating costs.

In the Virgin Islands, water consumption is thought to have increased from 87 million gallons in 1960 to 555 million gallons in 1968. Precise estimates of water consumption are extremely difficult to obtain, however, for records are not kept of water obtained from rain cisterns. The only accurate figures for

outlying resorts, except for Pineapple Beach which has overall cost estimates, relate to purchases from either the municipal system or the water trucking companies. Wherever possible, respondents were asked to refer directly to their records of bills, so that the estimates shown in Table 5 can be assumed to be reasonably accurate for that portion of the water supply. Figure 2 indicates the extent of seasonality of consumption, and Map 6 shows the geographical pattern for water consumed at these sites. The major consumers in Charlotte Amalie are the Virgin Islands Hilton and Yacht Haven. The large consumption at the latter arises from the heavy use of fresh water for washing and servicing the marina. Outside Charlotte Amalie, the concentration of water consumption at the eastern end of the island is readily apparent. The projected future growth at Sapphire Bay and Bolongo Bay Beach Club, apart from other resort complexes which may be expected to locate in the general area, indicates major water supply and sewage disposal needs on this end of the island during the next decade.

Some rough estimates of water cost may be useful in the ensuing discussion of water reuse. Using an efficient supply system of its own water truck, 48 rain cisterns, and a salt water flushing system, the management of the Pineapple Beach Club estimates their cost for water over the project life of the facilities at 7/10¢ per gallon ($7.00 per 1,000 gallons). With the guest consuming an estimated average of 200 gallons per day, this works out to a per guest per day cost of $1.40 and a per guest per year cost of $511. Yet this figure includes substantial reduction in cost because of the use of a salt water flushing system. A figure if water costs based on an entirely fresh water system would be closer to $1.85 per guest per day or 9/10¢ per gallon.

At the new Lime Tree resort complex, water is obtained from 11 cisterns of 80,000 gallons capacity each, the balance of fresh water from water trucking companies, and treated effluent is used for irrigation and cleaning. With a $6,000 water bill monthly at full occupancy and $16 for every 7 tons, per capita per day water consumption is approximately 122 gallons (excluding that from cisterns and treated effluent) at a cost of $1.12. Again, with an entirely fresh water system, assuming cisterns but no treated effluent, the costs would probably be about $1.40 per guest per day or about 1.2¢ per gallon. If the role of cisterns is assumed equal, this is probably quite close to the figures for Pineapple Beach Club.

With this background of present and projected water consumption and sewage disposal needs and some very rudimentary cost guidelines, let us now consider the development of decentralized water reuse systems in St. Thomas.

VI. PACKAGE TREATMENT PLANTS AND WATER REUSE

Package wastewater treatment plants have been in use for perhaps the last 10 to 15 years in areas of mainland United States. They are pre-engineered units with capacities ranging from 600 to 140,000 gpd and designed to serve shopping centers, resort complexes, apartment buildings, etc.[10] These plants remove 80 to 85 percent of the BOD (Biochemical Oxygen Demand) and suspended solids when properly operated and maintained. The survey by Reynolds of the performance of package treatment plants in St. Thomas indicates that even better effectiveness may be realized. He found some 53 treatment plants in use, of which 23 involved some direct reuse of chlorinated effluent.[11]

Our survey of tourist establishments indicates a trend away from septic tanks and toward package treatment plants. During the 1950's two of three resort complexes built installed septic tank systems; during the 1960's five of eight tourist establishments built installed package treatment plants. This change stems largely from legislation governing the design of sewage disposal systems passed under the Water Pollution Control Act of 1967. Since that act, the Health Department has required package treatment plants for sewage generated in excess of 2,000 gallons per day. Thus, all four complexes built since 1967 have utilized such facilities. The analysis to follow will demonstrate the wisdom of this action. Map 7 shows the geographical pattern of this growth of package treatment systems.

The six package treatment plants in the 18 sites studied are of two major types. The first, such as that employed at the Indies House and Cowpet Bay Village, is a fresh water system which reuses the effluent for flushing and irrigation. The second, such as that at Pineapple Beach and Secret Harbour, treats a mixed fresh and salt water (and in the case of Pineapple Beach brackish water) which is then returned to an adjacent maritime body. Both systems clearly result in substantial savings so that ready access to salt water or alternative sources may be the determining factor. There also is the initial benefit, not included here, of pollution abatement in adjacent maritime bodies. Indies House, for example, is at an inland location so that the reclamation of fresh water rather than a dual fresh and salt water system is the obvious choice. Cowpet Bay Village has access to an inexpensive fresh water well so that a fresh water reclamation system is probably more feasible. In any event, water is sold directly to the guests at this resort complex. Table 6 shows summary statistics for the six plants.

A detailed examination of several establishments provides some rough estimates of the cost of water treatment plants for sewage disposal. Assuming a 20-year project lift, an eight per cent discount rate and 100 per cent occupancy, the cost of sewage treatment at Lime Tree works out to $105 per guest per year. But these figures are for the first three months of the resort's operation; it is likely that these costs will come down. A similar calculation for Cowpet Bay Village

reveals a figure of $66 per guest per year. For Indies House, the figure is $69. These figures are not substantially different from the figure of $78 (or $95) for the cost of sewage disposal by septic tanks at the Pelican Beach Club. It should be noted that the Pelican Beach Club may not be representative of costs at other sites. Yet there is little evidence in our study of the rough rule of thumb cited by several respondents that septic tank systems cost only 50 per cent of that for package treatment plants.

But the latter has the added advantage of permitting reuse of the effluent, thereby reducing costs. Using figures derived from the tourist complexes studied, a hypothetical example may be used to analyze the economic feasibility of package treatment and reuse systems. Let us assume a new 50 unit resort complex with a 100 guest capacity located on the eastern end of St. Thomas. Let us further assume a cistern capacity of 200,000 gallons, the ability to buy water from trucking companies at $10 per 1,000 gallons, and a per capita consumption of 200 gallons per capita per day, of which cisterns will furnish 75 gallons per day. At 100 per cent occupancy, the management could expect an annual water bill of $45,625; at 75 per cent occupancy, the bill would be $27,375.

Given such a resort complex, what would be the net advantages or disadvantages of installing a septic tank disposal system versus a package treatment plant and reuse system? Let us assume that sewage disposal by a package treatment plant costs $80 per guest per year (the mean figure for the 3 package treatment plants cited above.) This would be an annual fee of $8,000 for the establishment under question assuming full occupancy. Let us further assume, to be on the conservative side, that a septic tank system could be installed at a half this cost, or $4,000 per year. It should be noted that such a cost differential is unlikely based upon our study results.

The package treatment plant would permit reuse of its effluent for flushing and lawn and garden irrigation. Managers continually estimated flushing and irrigation at 50 per cent or more of total consumption. This figure corresponds with estimates gathered in less arid areas of the United States where water savings fixtures are not employed. Even a one-third reduction in water consumption would, at full occupancy, result in savings of $23,725. After the $4,000 additional cost in the sewage disposal system is considered, a net savings of $19,725 has still been realized. From this must be deducted the additional capital investment required for the dual water supply system (piping and storage) but there can be little doubt that the reuse system can substantially cut costs where water supply is unusually expensive. Table 7 provides a summary analysis of the economic competitivness of reuse at varying occupancy levels. The recent actions and future plans by resort complexes indicate that they too share this belief.

VII. CONCLUSIONS

This study is obviously a preliminary effort to gather data relating to the water supply and waste disposal problems involved in the growth of a tourist industry in St. Thomas. The results indicate the key role played by water supply in the investment and operating costs of resort complexes, particularly those in areas distant from Charlotte Amalie. The data gathered in our interviews indicate that substantial economic savings are possible through water reclamation. There will, of course, be further growth in the use of such decentralized water reuse systems in the Virgin Islands, but the economic analysis contained in this report indicates the potential for package treatment and reuse systems elsewhere in the Caribbean.

VIII. APPENDIX

MAPS

FIGURES

TABLES

TABLE 1

SOURCE OF WATER SUPPLY FOR SELECTED TOURIST ESTABLISHMENTS (1971)

SITE	MUNICIPAL	CISTERN	WELLS	TRUCK	OTHER
Scott Hotel	X	X	X	X[1]	
Yacht Haven	X	X		X[1]	Salt water for flushing
Michele Motel	X	X			
Virgin Isle Hilton	X	X			Salt water for flushing
Carib Beach	X				Salt water for flushing
Indies House		X		X[2]	Reused water for flushing & gardening
Bluebeard's Beach Club		X		X[3]	
Cowpet Bay Village		X			Well water from Tutu & effluent for flushing
Lime Tree Hotel & Beach Club		X	X	X[2]	
Mafolie Hotel		X		X[2]	
Pineapple Beach Club		X		X[4]	Effluent for flushing
Pelican Beach Club		X		X	Salt water for flushing
Secret Harbor		X		X[2]	Treated salt water for flushing
Miller Manor	X	X		X[1]	Salt water for flushing
Tropic Isle	X	na			na
Sapphire Bay Resort		X		X[2]	Salt water for flushing
Pavillions & Pools		X	X	X[2]	
Bolongo Bay Beach Club		X	X	X[2]	

1. Water trucking for emergency only.
2. Regular contract with water trucking company
3. Bluebeard's Castle sends water to Beach Club by its own truck.
4. Pineapple Beach Club owns its own truck.

na: Data not available

TABLE 2

THE DISTRIBUTION OF CISTERNS AMONG TOURIST ESTABLISHMENTS

SITE	NUMBER OF CISTERNS	TOTAL CAPACITY	FUNCTION
Scott Hotel	1-85,000 gallons	85,000 gallons	all
Yacht Haven	5-35,000 each 1-48,000	223,000	ingestion cooking
Michele Motel	3	na	all
Virgin Isle Hilton	3-50,000 each	150,000	ingestion
Carib Beach	0		
Indies House	1-113,000	113,000	all
Bluebeard's Beach Club	24-8,000 each	192,000	ingestion
Cowpet Bay Village	15-50,000 ave.	750,000	condominium use
Lime Tree Hotel and Beach Club	7-80,000 each 3-80,000 each 1-80,000	880,000	guest use kitchen use snack bar
Mafolie Hotel	4-18,750 each	75,000	guest use pool
Pineapple Beach Club	2-80,000 each 1-40,000 1-75,000 1-150,000 1-60,000 40-18,000 each	1,205,000	ingestion guest use dining flushing
Pelican Beach Club	17-8,000 ave.	136,000	everything but flushing
Secret Harbour	1-100,000 1-45,000	145,000	everything but flushing
Miller Manor	2-18,000 each 1-50,000	86,000	ingestion
Tropic Isle	na		
Sapphire Bay Resort	1-750,000 3-25,000 each	825,000	guest use watering of landscape
Pavillions & Pools	12	na	ingestion showers
Bolongo Bay Beach Club	1-10,000	10,000	ingestion guest use

TABLE 3

VISITORS TO THE U.S. VIRGIN ISLANDS BY METHOD OF ARRIVAL

(1964-1970)

METHOD OF ARRIVAL	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
BY AIR	354,371	436,775	516,295	651,098	908,776	n.a.
BY SEA*	84,653	100,00	95,066	105,810	156,975	n.a.
BY CRUISE SHIP	109,341	117,659	133,357	166,117	213,541	251,084
TOTALS:	548,365	654,434	744,718	923,025	1,279,292	n.a.
NUMBER OF MOTEL BEDS	3,911	4,345	5,615	6,223	7,004	n.a.

*NOTE: These sea arrivals are for Armed Services, private yachts, and regular steamers.

n.a.: Data not available

SOURCE: Virgin Islands Department of Commerce, Visitors Bureau

TABLE 4

PRESENT GUEST CAPACITY AND PROJECTED GROWTH FOR SELECTED TOURIST ESTABLISHMENTS
(1971)

SITE	Number of Rooms or Units	Projected Unit Growth for Next 10 Years	Percentage Growth
Scott Hotel	28	0	0
Yacht Haven	76	Major expansion planned - 332 units possible	337?
Michele Motel	40	14	35
Virgin Isle Hilton	209	0	0
Carib Beach	90	150	166
Indies House	32	40	125
Bluebeard's Beach Club	24	0	0
Cowpet Bay Village	102	60 and hotel	59
Lime Tree Hotel	85	20	24
Mafolie Hotel	23	40	174
Pineapple Beach Club	200	n.a.	n.a.
Pelican Beach Club	20	6	30
Secret Harbour	40	30	75
Miller Manor	32	0	0
Tropic Isle	16	n.a.	n.a.
Sapphire Bay Resort	118	200	169
Pavillions & Pools	24	0	0
Bolongo Bay Beach Club	18	65 rooms and 44 condominiums	500

n.a.: Data not available

TABLE 5

MANAGERIAL ESTIMATES OF WATER PURCHASES, 1970

SITE	Water Purchases (in Thousands of Gallons)	Cost (per 1,000 Gallons	Total Cost of Water Purchased
Scott Hotel	Unavailable	$2.00	Unavailable
Yacht Haven	15,000	2.00	$30,000
Michele Motel	875	2.00	1,750
Virgin Isle Hilton	18,000	2.00	36,000
Carib Beach	6,000	2.00	8,400
Indies House	1,288	8.10	10,594[a]
Bluebeard's Beach Club	1,352	2.00[b]	9,500
Cowpet Bay Village	1,300[e]	10.00[f]	3,000[f]
Lime Tree Hotel	Unavailable	9.16	Unavailable
Mafolie Hotel	443	8.00	3,538
Pineapple Beach	10,000	7.00c	50,000
Pelican Beach Club	513	16.00	8,200
Secret Harbour	609	10.00	6,095
Miller Manor	304	2.00	626[d]
Tropic Isle	896	2.00	1,792
Sapphire Bay	5,475	9.00	60,000
Pavillions & Pools	420	10.00	4,200
Bolongo Bay	267	10.00	2,669

a. 11 month total
b. Initial fee of $2.00 plus transportation costs. Bluebeard's Castle ships water to Bluebeard's Beach Club in its own water truck.
c. Figures included total volume of water consumed, rate of cost is for the truck owned by the establishment, and the total cost of water supplied by all sources.
d. 10 month total
e. of which 300,000 is from water trucks and 1,000,000 from well in Tutu
f. includes only water from trucking companies

TABLE 6

SUMMARY STATISTICS FOR PACKAGE TREATMENT PLANTS AT SELECTED SITES

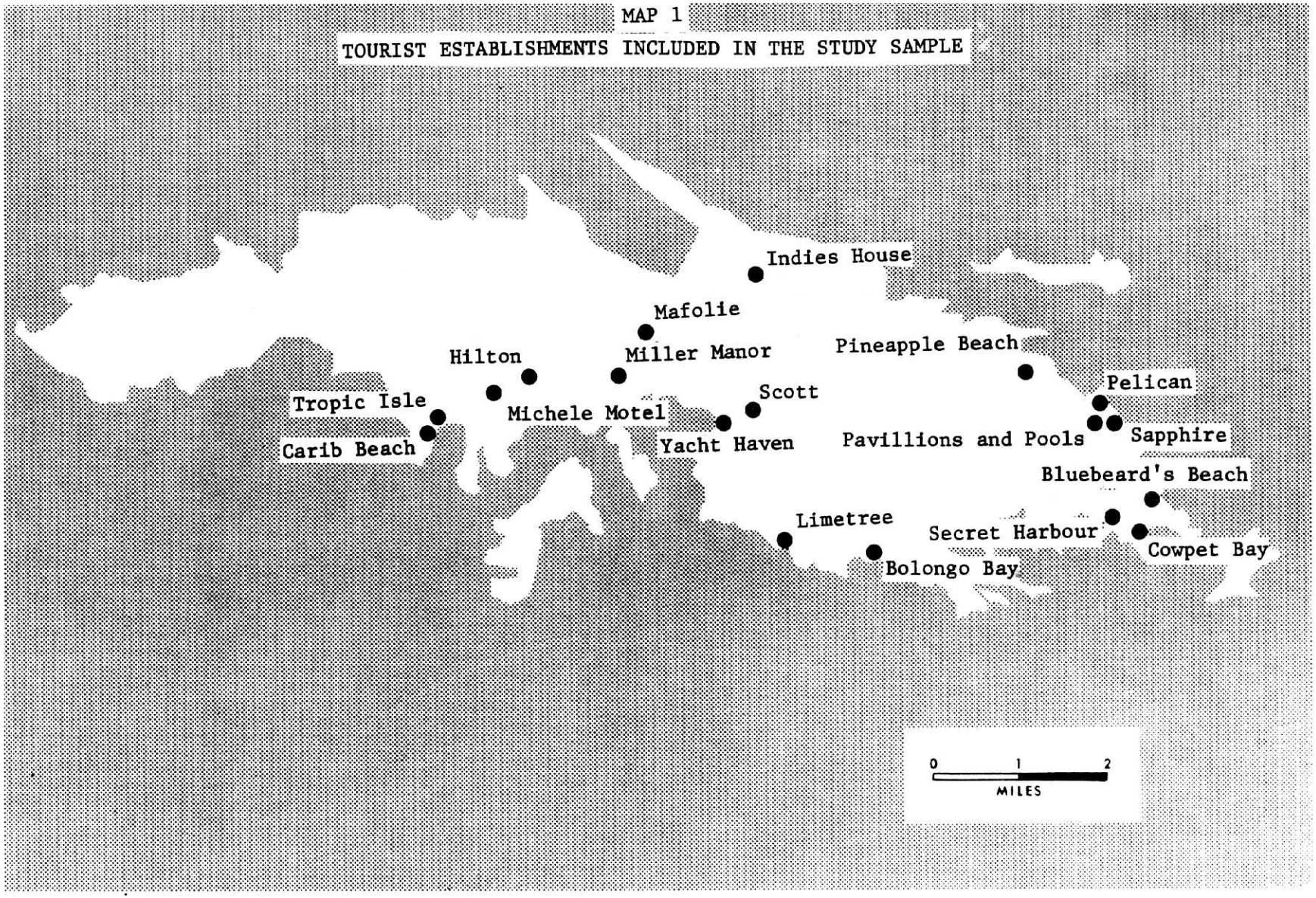
Site	Type	Date Treatment Installed	g.p.d. Capacity Treatment	Installation Cost	Annual Operating Cost	Use of Effluent	Projected Expansion
Indies House	Conglomerate System: Fresh Water	1968	8,500	$20,000	$1,800	flushing, irrigation	another holding tank
Cowpet Bay Village	Chicago Pump Fresh Water	1967	25,000	$35,000	$9,000	flushing, irrigation	new plant-80,000 gpd
Lime Tree	Dafco: Aeration and Lift station	1969	47,000	$45,000	$12,000	flushing, irrigation	none
Pineapple Beach	Dafco; mixed salt and brackish well water	1969	45,000	$80,000	$10,000+	piped to bay	tertiary treatment; $25,000 of electric generators to be installed
Secret harbour	Dafco; salt water sanitary system	1968	25,000	N.A.	$1,000	piped to sea	none
Sapphire Bay	Chicago Pump: Salt Water	1969	50,000	N.A.	$18,000	piped to lagoon	tertiary treatment

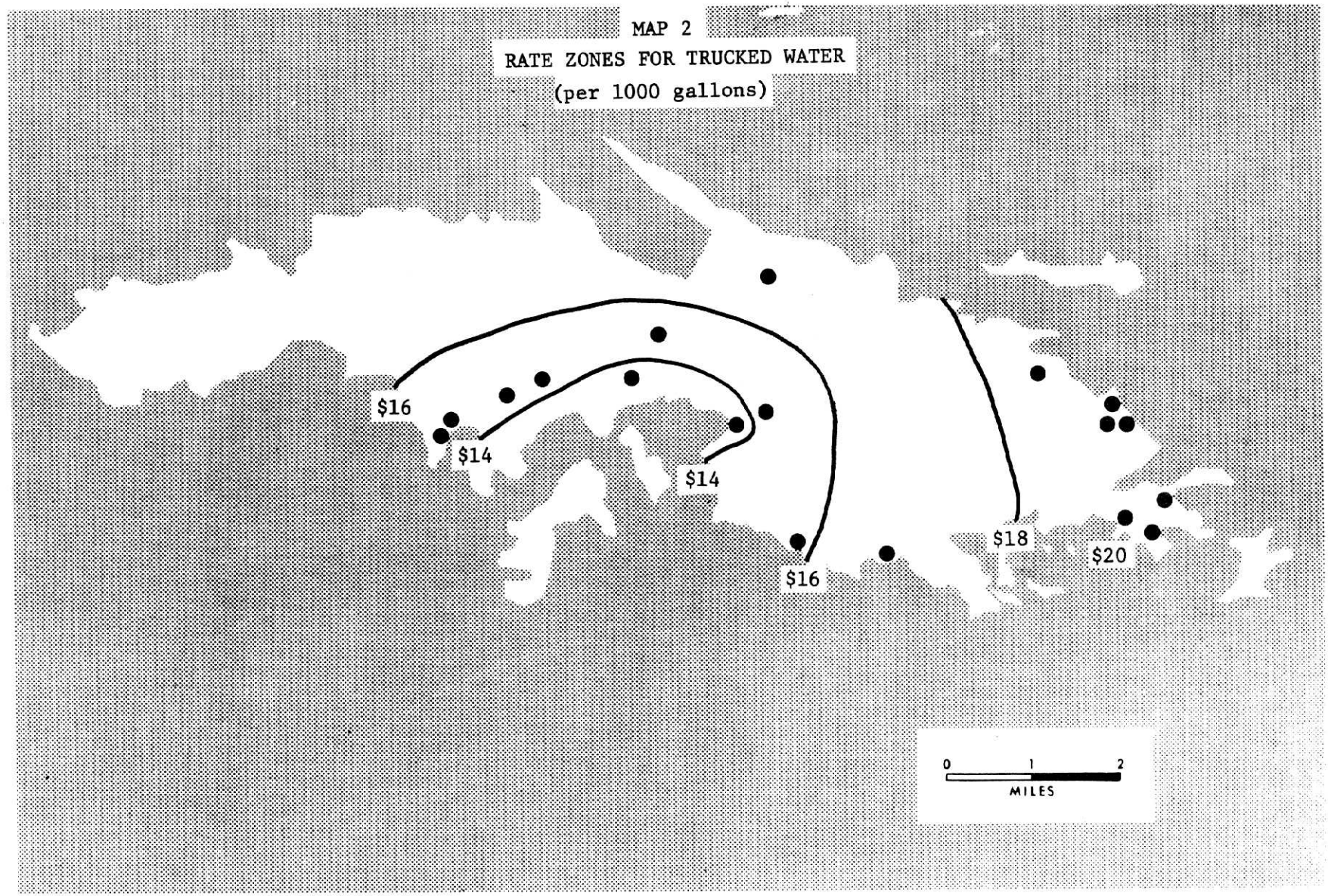
TABLE 7

NET COSTS AND SAVINGS OF A WATER REUSE SYSTEM AT AN HYPOTHETICAL TOURIST RESORT WITH A 100-GUEST CAPACITY

	% OCCUPANCY			
	25%	50%	75%	100%
Total Daily Water Required[1]	5,000	10,000	15,000	20,000
Water From Cisterns	7,500	7,500	7,500	7,500
Water Purchases (@$10.00 per 1,000 Gallons)	-	2,500	7,500	12,500
Annual Cost of Water[2]	-	9,125	27,375	45,625
Water Provided through Reuse (1/3 of total Consumption)[3]	-	3,500	5,000	6,500
Daily Water Purchases with Reuse System	-	-	2,500	6,000
Annual Cost of Water with Reuse System	-	-	9,125	21,900
Annual Savings on Water Cost with Reuse System	-	9,125	18,250	23,725
Extra Cost of Package Treatment Plant[4]	3,400	3,600	3,800	4,000
Net Annual Cost of Reuse System	3,400	-	-	-
Net Annual Savings of Reuse System	-	5,525	14,450	19,725

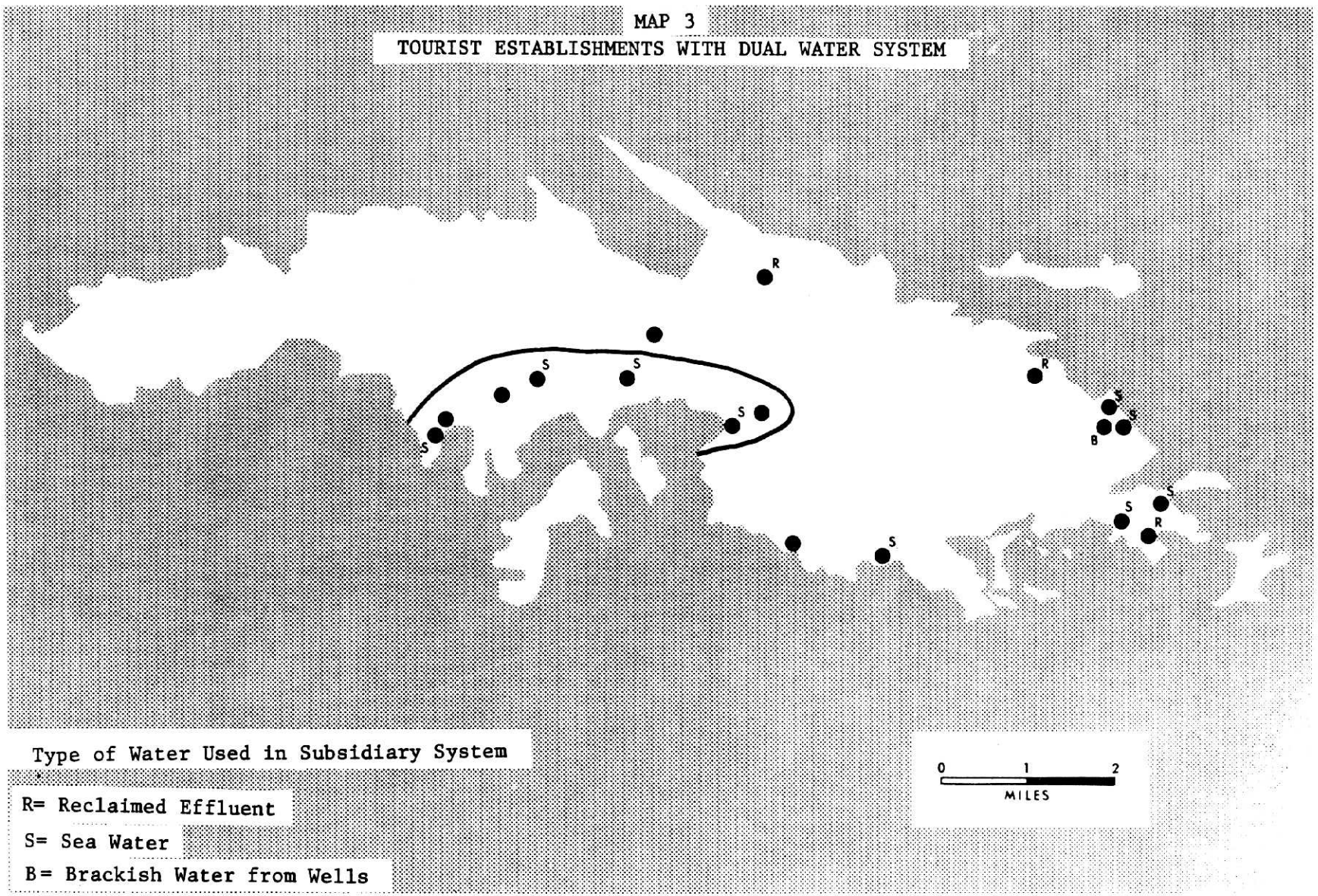
1. Assuming an average per capita consumption of 200 gallons per day. including irrigation, swimming pool, and maintenance uses.
2. Excluding cistern costs which are here assumed c onstant with alternative systems. The assumed cistern capacity is 200,000 gallons.
3. Figures rounded.
4. Over the cost of a sewage disposal system using septic tanks. Calculations assume that package treatment costs include an initial $3,200 fixed cost and an operational expense of $200 per 25% capacity at the given scale.


MAP 1
TOURIST ESTABLISHMENTS INCLUDED IN THE STUDY SAMPLE
Indies House
Mafolie
Hilton
Miller Manor
Pineapple Beach
Pelican
Tropic Isle
Michele Motel
Scott
Carib Beach
Yacht Haven
Pavillions and Pools
Sapphire
Bluebeard's Beach
Limetree
Secret Harbour
Cowpet Bay
Bolongo Bay
0
1
2
MILES


MAP 2
RATE ZONES FOR TRUCKED WATER
(per 1000 gallons)
$16
$14
$14
$16
$18
$20
0
1
2
MILES

MAP 3

TOURIST ESTABLISHMENTS WITH DUAL WATER SYSTEM



Type of Water Used in Subsidiary System

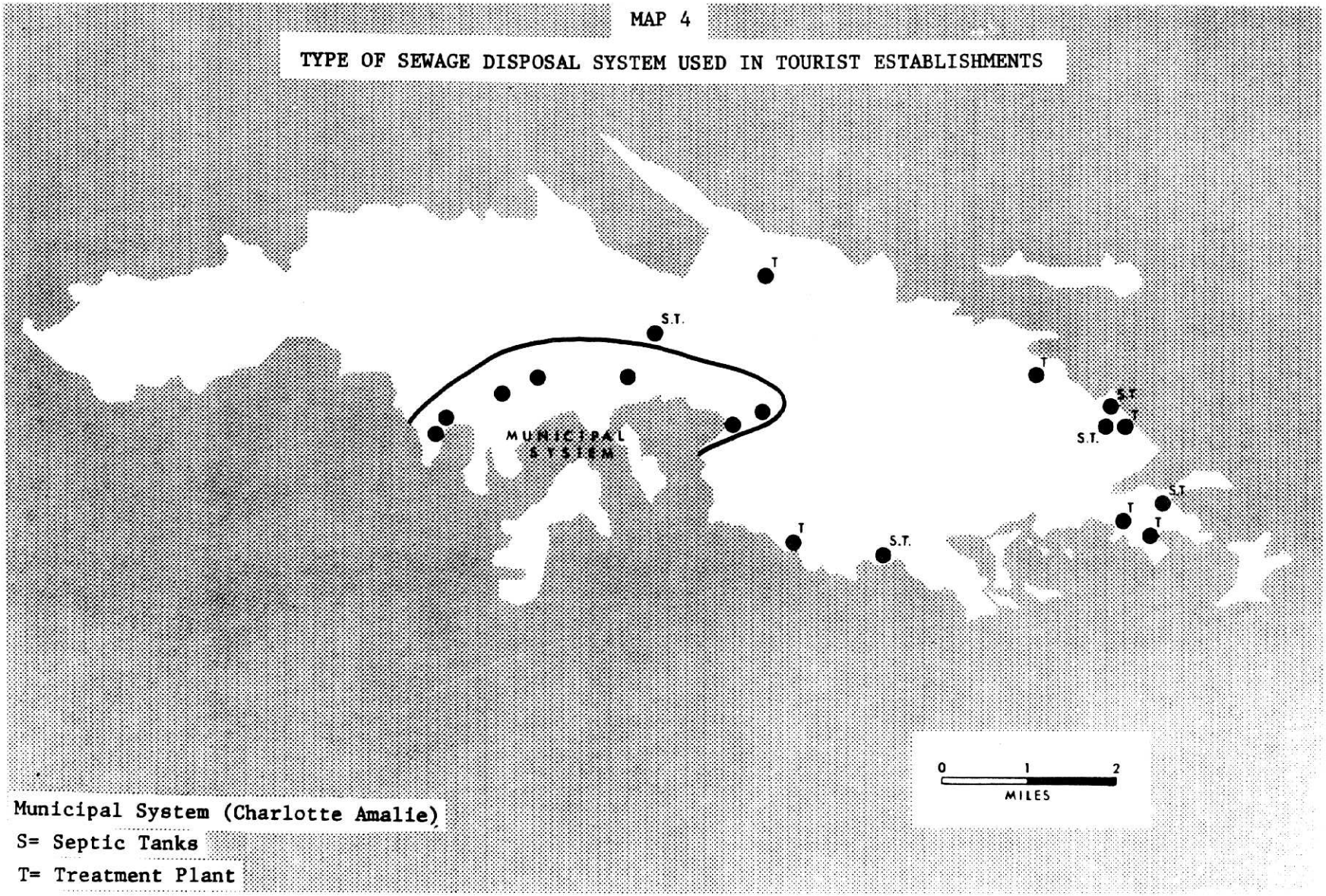
R= Reclaimed Effluent

S= Sea Water

B= Brackish Water from Wells

MAP 4

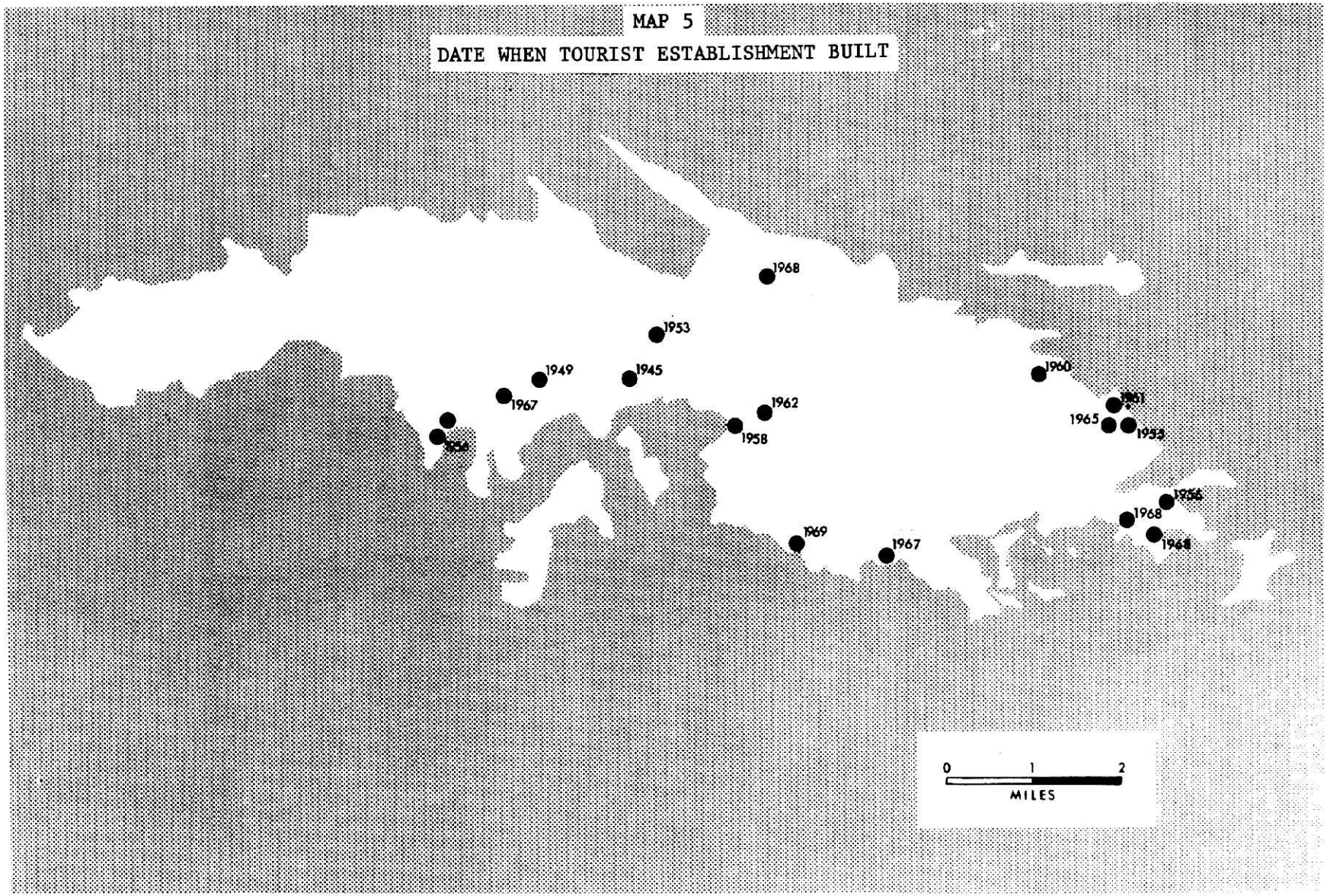
TYPE OF SEWAGE DISPOSAL SYSTEM USED IN TOURIST ESTABLISHMENTS



Municipal System (Charlotte Amalie)

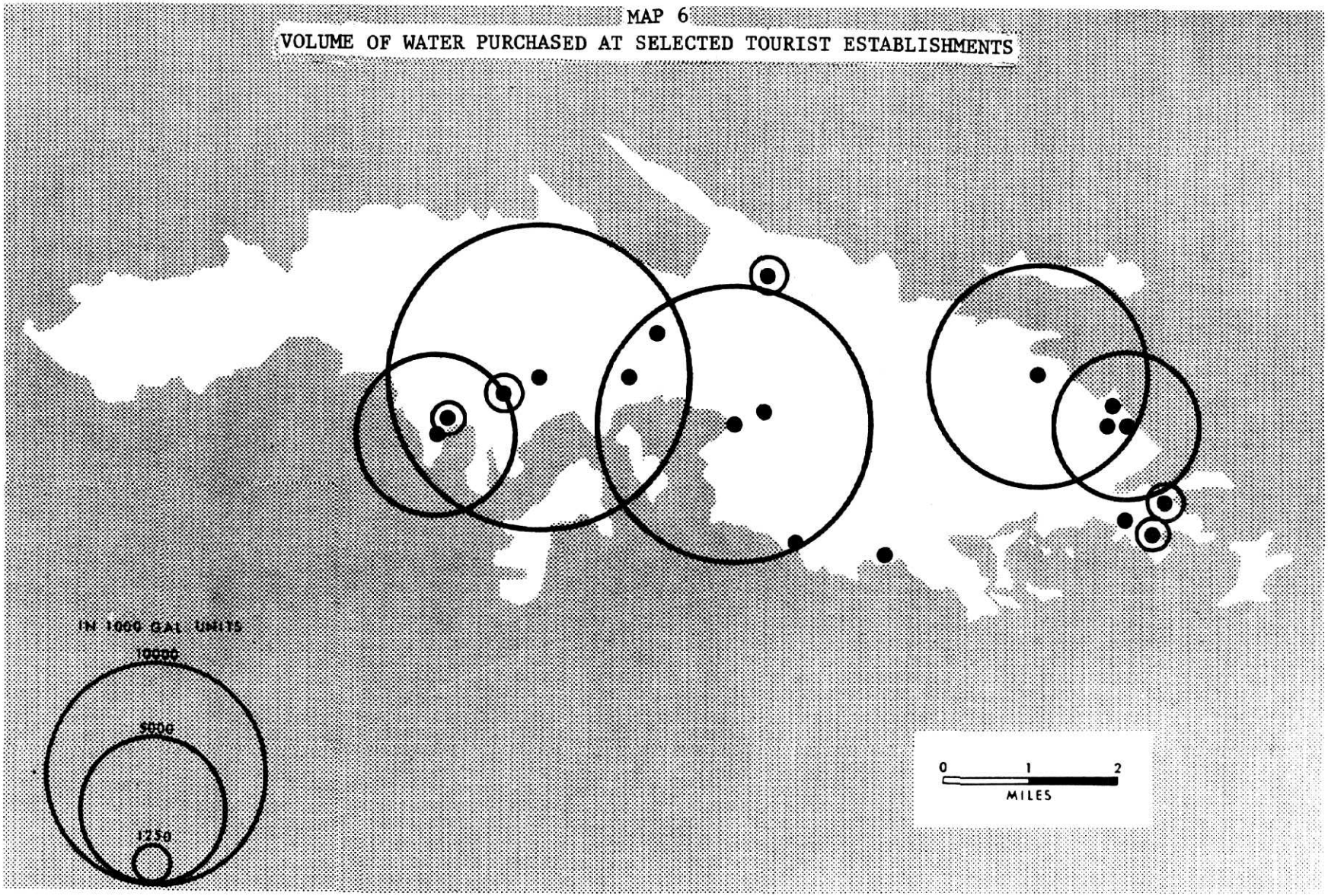
S= Septic Tanks

T= Treatment Plant


MAP 5
DATE WHEN TOURIST ESTABLISHMENT BUILT
1968
1953
1949
1945
1967
1962
1958
1960
1965
1956
1968
1969
1967
0
1
2
MILES

MAP 6

VOLUME OF WATER PURCHASED AT SELECTED TOURIST ESTABLISHMENTS



MAP 7

PACKAGE TREATMENT PLANTS AT TOURIST ESTABLISHMENTS
(by year built and capacity in thousand gallons per day)

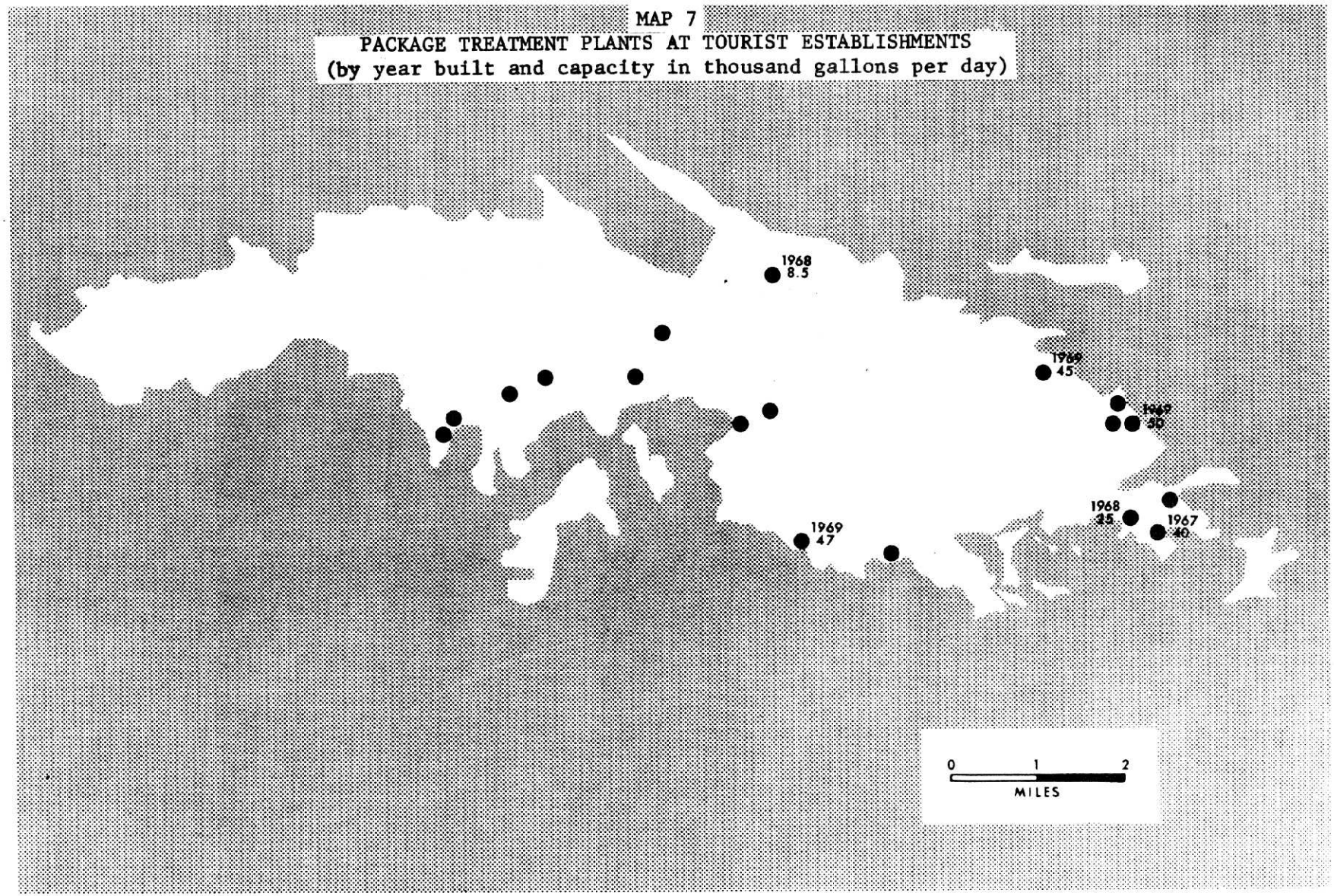
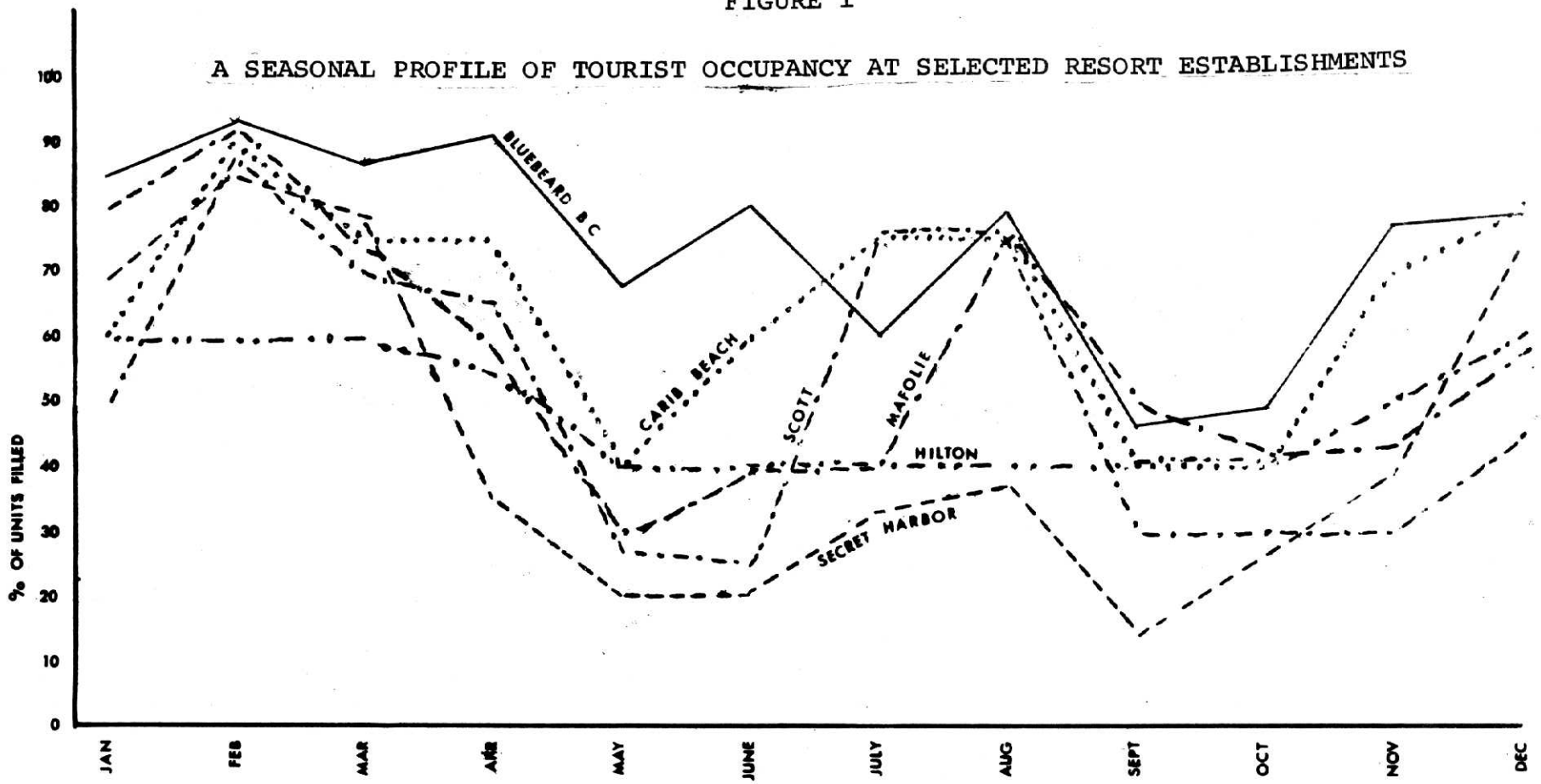


FIGURE 1

A SEASONAL PROFILE OF TOURIST OCCUPANCY AT SELECTED RESORT ESTABLISHMENTS



Indies House	December-March	85%	Sapphire Bay	January-April	60-65%
	April-November	30%		May-December	35-40%
	Overall-55%				

FIGURE 2

CUMULATIVE WATER PURCHASES FOR SELECTED ESTABLISHMENTS

(1970)