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ROOKERY BAY LAND USE STUDIES

ENVIRONMENTAL PLANNING STRATEGIES FOR THE DEVELOPMENT OF A MANGROVE SHORELINE

STUDY NO. 6

"APPLICABILITY OF THE INTERCEPTOR WATERWAY CONCEPT TO THE ROOKERY BAY AREA"

by

Eric J. Heald and Durbin C. Tabb

Tropical BioIndustries Development Company
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THE ROOKERY BAY AREA STUDY PROGRAM

The mangrove shores and islands, the bays and lagoons, and the marshes and creeks of the southwest Florida coast are a natural resource unit of exceptional value that support a rich and varied population of fish, birds, and wildlife. Yet the accelerated shore development of the 1950's and the 1960's caused widespread environmental damage wherever it collided with these beautiful and productive estuarine areas. With little appreciation of ecological principles of land use and water management, shorelands were stripped of mangroves, bay bottoms were scoured for land fill, and waters polluted with silts, nutrients, and bacteria. The unique and haunting loveliness of the shorelines of Tampa Bay and Ft. Meyers were largely replaced by the geometry of development.

South of Naples, a large part of the mangrove shoreland remained undeveloped -- but threatened. This region is now beginning to experience the pressures of waterfront development: construction of drainage canals, dredging of estuaries, and ripping out and filling of mangrove swamps. Uncontrolled, this movement will destroy much of the area's natural value; if future development does not respect the vital elements of the mangrove-estuary environment, coastal Florida will lose the very qualities that have attracted people to it.

Ecologically sound land-use planning can provide a basis for solving much of the coastal land-use dilemma. The intensity of conflict between developmental stability, and the unusually high values of south Florida's natural resources, make this an ideal region for exploring ways of reconciling these major land-use conflicts. In recognition of this, the Conservation Foundation, in 1967, launched a demonstration planning project centering on the Rookery Bay region between Naples and the Ten Thousand Islands, an ecosystem characteristic of the mangrove-estuarine environment of south Florida. Rookery Bay itself, and the mangrove shores immediately surrounding it, are held as a wildlife sanctuary by the National Audubon Society. Lands surrounding the Sanctuary are still largely undeveloped, but most are in private ownership and development pressure is building strongly. Such development not only threatens the Sanctuary, but could threaten the entire Rookery Bay estuarine ecosystem.

The original goal of the Foundation in undertaking the study was to determine the extent and kind of development which the area could support without destroying the natural estuarine ecosystem. The project was conducted by Foundation staff and consultants through a series of environmental and cultural studies designed to show how development could proceed in ways that respected both environmental fundamentals and economic imperatives.

The study was carried out in two phases. The first, supported primarily by the Ford Foundation, ended in 1969. The major report of this study, Rookery Bay Area Project, was published by the Conservation Foundation in 1968. It presented a trial plan for development which would leave the mangrove forests intact in the interest of protecting the Sanctuary ecosystem.

The second phase, supported primarily by the U.S. Department of the Interior, Office of Water Resources Research, extended from 1970 to mid-1973. It was designed to obtain extensive biological, physical, social, and economic data and to devise methods to incorporate these data into planning strategies designed for compatibility between development and environmental quality. One specific goal was to predict in detail the environmental consequences of the 1968 trial Rookery Bay development plan. Another was to provide the technical basis for a second generation plan and to determine its usefulness to a wider area of the coastal zone and a broader spectrum of effects.

This study is one in a series by Conservation Foundation and University of Miami consultants and staff members reporting individual aspects of the second phase studies. The conclusions reported are those of the authors and do not represent the views or policies of either the Conservation Foundation or the Office of Water Resources Research.

Arthur A. Davis
Vice President-Operations
The Conservation Foundation

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APPLICABILITY OF THE INTERCEPTOR WATERWAY CONCEPT TO THE ROOKERY BAY AREA

This document presents an analysis of the utility, feasibility and applicability of the Interceptor Waterway[1] Concept as a land development aid in the vicinity of the Rookery Bay Sanctuary, Collier County, Florida. It attempts to indicate those areas in which the Interceptor Waterway could be employed to ecological advantage, and considers the ecological factors involved and possible design criteria to be employed.

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[1]A wide, shallow waterbody, as defined by Tabb and Heald (1973).

CONCEPT

When the Rookery Bay Sanctuary concept was initiated in 1964 and certain tracts within the coastal zone were acquired as a result of the efforts of the Naples community, the possible effects of future urban development on the Sanctuary were seriously discussed. One suggestion for separating such development from Sanctuary lands was the Perimeter Canal.[2]

The basic assumption was that urban development, if prohibited within the truly estuarine areas (and the Sanctuary in particular), would nevertheless proceed to some degree on adjacent upland areas. The Perimeter Canal proposed in 1968 was to be the physical boundary of the Sanctuary on its upland side. However, land purchases since then have enlarged the Sanctuary beyond the proposed location of the Perimeter Canal, and the need for such a physical boundary may now be less critical because of changed thinking in the general field of land-use control and public acquisition for environmental purposes.

However thinking regarding land use may have changed, the Perimeter Canal concept was originally formulated with the expectation that marshlands immediately upland of major mangrove associations (i.e., high elevation black and white mangroves and saline grass or sedge marshes) would be used for development. As recently as 1971, the use of public money for acquisition of such lands did not appear to be realistic or acceptable.

However, the recent emergence of strong public sentiment toward preservation of all marsh areas, saline or fresh-water, makes public acquisition of undeveloped "buffer zones" a more tenable concept. One of the major purposes of the Perimeter Canal (and particularly of its successor, the Interceptor Waterway) was to replace extensive upland marsh areas as assimilators of heavy concentrations of dissolved primary nutrients and assorted pollutants emanating from development complexes on adjacent upland areas. If high-marsh areas can be acquired and thus preserved, they can be expected to perform the nutrient "scrubbing" function provided that they are large enough in extent to absorb the nutrient input load without a subsequent reduction in efficiency.

There is, however, a marked paucity of quantitative data available concerning the nutrient assimilation capabilities of any specific marsh community in the sub-tropics. Theoretically a grass marsh high in basic productivity will be able to assimilate large poundages of primary nutrients on a per acre basis, but we have little idea of how much -- and this makes planning decisions undesirably subjective.

If we knew, for example, how many pounds of nitrogen a single acre of spike-rush marsh could safely remove from water flowing through it, we could plan accordingly. However, parameters such as the speed of water flow

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[2] "Perimeter" refers to the 1968 concept described in The Rookery Bay Area Project, Conservation Foundation; the terms "canal," "waterbody," and "waterway" are used interchangeably.

through the marsh will affect this, as will the effective water height at any particular time of year.

A further complicating factor is presented by the simple fact that natural ecosystems react to changes. One can hardly expect a delicate system such as a marsh to absorb an increased dissolved nutrient level or suspended sediment load and remain unchanged in character. At some undetermined loading level, or at some point in time, these influences will be felt. The marsh may begin to build up its own elevation in places, causing water to be channelized to a greater extent and absorptive filtering surfaces to be removed from the "system." With such buildup, and it only need be measured in centimeters, plant succession can be expected and the marsh will change in character.

It thus would appear advisable to insert where possible an additional "safeguard" into the water flow system before water enters the Sanctuary. It seems logical that the more "in-line filters" a system contains the less will be the load on the final filter. Consequently, a flow system that follows the sequence -- upland retention ponds:marsh:Interceptor Waterway: mangrove-estuary -- should often be superior to one which omits one or more of these stages.

In locations where an extensive marsh area is not present between developable uplands and tidal mangroves, some mechanism must be employed to slow the rate of entry of runoff waters into the truly tidal areas and to perform an intermediate scrubbing service. The Interceptor Waterway can be useful in this capacity.

The experience gained since 1968 in marine shrimp culture programs, and the pond management techniques developed in these programs, have made it possible to estimate the assimilatory capacity of the Interceptor Waterway concept, and design modifications have been made accordingly (Tabb and Heald, 1972; Tabb et al., 1973). Consequently the "safe performance limits" of the waterway are predictable at a reasonable level of confidence.

Of practical importance, if the Interceptor Waterway, or similar "scrubbing device," does become loaded with nutrients or sediments in excess of its assimilatory capacity, and does develop thick mats of algae or rooted vegetation, it is far easier to institute a maintenance program in such an accessible body of water than to attempt to clean out and restore a choked marsh area. Furthermore, signs of deterioration are more readily recognizable and monitoring is more feasible in an accessible body of water.

When considering the relative utilities of grass marshes and an interceptor-type waterway, it should be stressed that, for the most part, the latter will not operate at maximum efficiency in those portions of Water Management District #6[3] most closely associated with the Sanctuary. The

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[3]A study district established for planning purposes by Collier County; it embraces the nominal watershed (41,000 acres) of the Rookery Bay area.

primary reasons for this are: (a) deep cypress sloughs which are difficult to traverse effectively without major engineering modifications and which would interrupt the continuity of the waterway; and (b) the extensive inland boundaries of the Sanctuary ownership tend to force the siting of a waterway inland of the influence of any tidal regime. This eliminates the import-export advantages conferred on the waterway system by the passage of marine and estuarine organisms over its seaward margin during certain stages of the tide.

The other major ecological function of the Interceptor Waterway is water distribution. The waterway is designed to intercept fresh-water runoff at localized points as it leaves a developed area, move it laterally along a broad front, and release it more or less uniformly at all points over a controlled level sill along the seaward margin into the mangrove zone.

If the Interceptor Waterway is not required as a nutrient scrubbing device in any specific instance, by virtue of the retention of large areas of high-marsh by land purchase or regulation, some system may be required nevertheless to assure uniform distribution of water flowing from upland developed areas into this marsh. Discharge of runoff waters at localized points without spreading will not produce the sheet flow of water through the entire marsh which is necessary for nutrient removal. Thus, some form of an interceptor waterbody might be indicated for this purpose, if for no other.

We are now of the opinion that the Interceptor Waterway concept, in its total function as a nutrient scrubbing mechanism, water distributor, and physical buffer, may have limitations within the Water Management District #6. It cannot operate at maximum efficiency unless it has a tidal component. This is not possible if all saline marsh areas are to be preserved. However, it can still be a useful water management tool and fulfill certain functions even if sited less favorably. We will proceed now to appraise these possibilities for the Rookery Bay area.

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APPLICATION

Preliminary recommendations of environmental planners for Water Management District #6 are to limit high density development for the most part to areas east of U.S. 41, by restricting most development to lands higher than 5½ feet above mean sea level (M.S.L.).

Fresh-water runoff from these proposed future urban areas will be routed into adjacent cypress sloughs via upland polishing ponds and collector ditches. The collector ditches will be designed with control structures to force all fresh-water runoff into the sloughs except at extreme high water periods. As water passes through the sloughs, it will be collected and conveyed where necessary under U.S. 41 and released to cypress sloughs west of the road. From these points it will proceed seaward through the sloughs and into saline marsh and mangrove areas before reaching open water.

The effect of the 5½-foot minimum building elevation is that upland (pine and palmetto mostly) areas west of U.S. 41 will primarily be designated as areas of "Conservation" (C) in which very limited development is to be permitted. All cypress sloughs and marsh areas (fresh-water and saline) are assigned to "Protection" (P) and no development is to be allowed.

The demarcation line of "Preservation" and "Conservation" between Naples Bay and Henderson Creek produces five wide finger-like projections separated by southwesterly oriented cypress sloughs. We have, for the purposes of this report, designated these (from northwest to southeast): C1, C2, C3, C4, and C5, and have considered the applicability of the Interceptor Waterway to each.

<u>Area C1</u>: The most northern projection offers perhaps the greatest number of alternatives and has been somewhat neglected in the proposed Water Management District #6 plan. The plan allows intensive development and a marina complex adjacent to the Lely Canal on the landward edge of the marsh areas. The Lely Canal and its associated cypress slough is incorporated into the nutrient scrubbing and water conveyance system originating northeast of U.S. 41.

The plan makes no provision for fresh-water runoff collection or distribution from C1. From the contour map provided, it would appear that the natural surface drainage flow would be predominantly southwest along minor sloughs, entering the mangrove forests bordering Shell and Dollar bays. If this is the case, it would be unwise to divert or to allow runoff waters from urban developments to the "Lely Slough." Serious consideration should be given to the use of the Interceptor Waterway concept on the southwestern margins of this area.

Without information on tidal amplitudes and mean tidal ranges in the immediate area, we would have to speculate that, to function at maximum efficiency, the seaward margin of the waterway would need to be at approximately 1.9 to 2.0 feet above mean sea level in Area C1, and would be placed at or near the landward margin of the mangrove community (perhaps coinciding with the C/P demarcation line, or slightly seaward of it). At this elevation, or at whatever elevation is appropriate, it would receive tidal waters frequently enough to function at maximum efficiency. The operative principle is that tidewater should flow into the waterway over its seaward edge on approximately 1/3 of all high tides during the year. The majority of such tides will cause only one or two inches depth over the waterway margin. Extreme spring tides will produce depths over the "sill" of eight inches to one foot.

Until we know the approximate land-use and development mix in Area C1, and hence can derive an approximation of the amounts of dissolved nutrients to be expected in runoff waters, it is of little avail to suggest detailed specifications of total acreage required for the waterway. We can only make reference to the appended publications (Tabb and Heald, 1972; Tabb et al., 1973), which outline the cross sectional dimensions, slopes, bank treatment and assimilative capabilities of the waterway, diagramatically shown in Figures 1 and 2. As a rough rule of thumb, we have found previously that an urban development housing 20,000 people required 1,000 surface acres of waterway to provide reasonable assurance of adequate quality water entering the estuarine system. This figure is, of course, largely dependent upon the relative percentages of absorptive "greenspace," polishing ponds, and impermeable surfaces.

Spoil produced by dredging or draglining to create artificial waterbodies, whether these be upland lakes or interceptor canal sections, should be hauled to upland sites for use as fill.

There will be considerable disruption of the marsh during such operations, but we propose that draglines use existing roads or levees to enter the digging site where such exist. From that point, all work and wheeled traffic would be restricted to the upstream side of the newly dug waterway. In time this will create a 40- to 60-foot roadway along the entire upstream side of the waterway which can, once dredging is terminated, armour the waterway edge against future erosion. During construction this roadway should be penetrated by numerous culverts of sufficient size to prevent water impoundment and "drowning" of vegetation upland of the newly created road.

Upon completion of the waterway the roads should be leveled to original marsh soil grade <u>or</u> the culvert openings originally installed should be supplied with one-way flap valves and then put under a careful monitoring schedule to insure that they do not become clogged.

The waterway could be designed to accept almost all the fresh-water runoff from the developed area to the north and, if desired, could be connected to the marina in the south and Naples Bay in the north by water level control structures situated to assure seaward flow over its western margin during the rainy season. A possible alignment is suggested in Figure 3. Operation of the waterway would, however, be simplified if no connections were incorporated at either end.

<u>Area C2</u>: Provided with a large lake and overland drainage leading eventually to Stopper Creek, this area appears to be adequately served, and

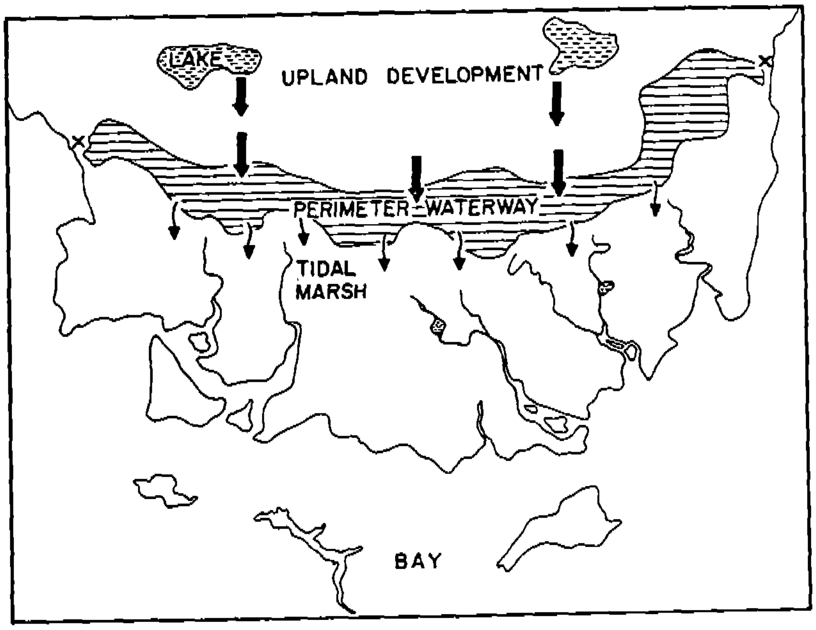


Figure 1. The lateral distribution of runoff water by a perimeter waterway. Points of controlled boat access to the waterway are marked X.

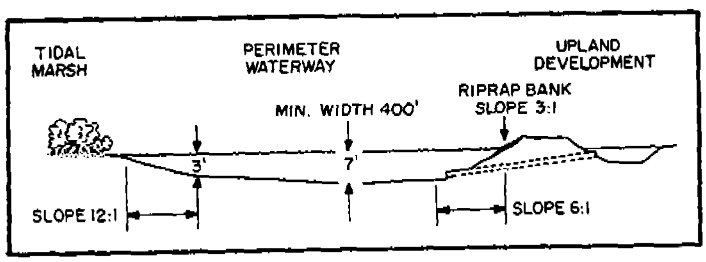


Figure 2. Cross-section of the perimeter waterway.

Source: Tabb, Durbin C., E.J. Heald and R.G. Rehrer. "Innovations in Coastal Management," University of Miami, 1973.

should present no problems to the Sanctuary.

Area C3: A relatively narrow finger of upland which is designated "C" in its entirety. Runoff waters could be directed into a collector-distributor waterway (fulfilling one of the functions of the Interceptor Waterway) before entering the fresh-water sloughs to the north and south. A wide, large volume waterway to accept and scrub runoff water from this area is not only unnecessary but is wasteful of land.

Relieved of its scrubbing function, the Interceptor Waterway thus becomes, in this instance, primarily a water distribution device and its design criteria need be less specific. However, a certain amount of nutrient assimilation will be possible, in fact, inevitable, within the waterway. Consequently, the waterway must still conform to certain criteria in order to avoid stagnation and deoxygenation of bottom waters.

These criteria will depend to some degree on the nature of the soils and on the amount of water expected to enter the waterway. In general, however, it should not be less than 100 feet in width, and should not exceed three feet in depth, except at high water periods, when a maximum water depth of five or six feet would be permissible. Banks above and below the normal water level should be sloped at 4:1 or 5:1 and stabilized with rip-rap type materials.

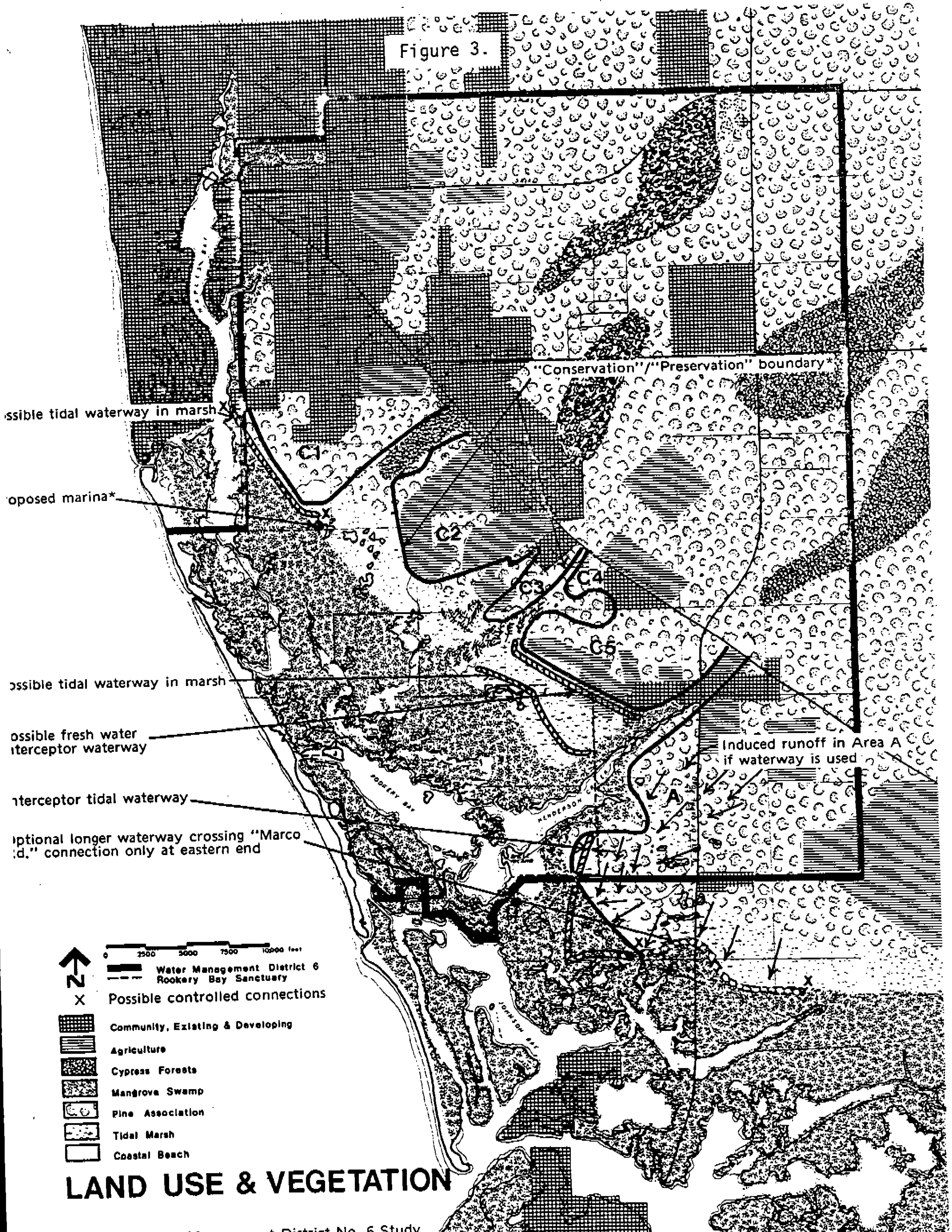
Area C4: Similarly, this is a small watershed area which could be served by a collector waterway.

Area C5: A large area of uplands bounded on the south by S.R. 951, and abutting the Rookery Bay area on the north is a potential problem area. Developmental pressures are perhaps most likely to occur in this area, and its strategic location imparts particular importance to the quality of runoff water leaving it.

The soils in this area have, for the most part, apparently poor drainage characteristics and consequent high water table during the rainy season. This means that elevated ground levels will be required for development purposes. This will, in turn, increase the rate of surface runoff.

Runoff water cannot be allowed to enter Henderson Creek directly, nor should it be directed into the slough to the north. This slough is expected to accommodate land drainage from developed areas east of U.S. 41, and in a relatively short distance it enters the tidal region of Stopper Creek. It is unwise to overestimate its ability to assimilate residual nutrients or pollutants from two major sources. Consequently, water draining from Area C5 should be directed through the fresh and brackish water marshes adjacent to and within the Sanctuary.

Even if upland retention lakes are incorporated into an overall development plan for Area C5, it would seem a wise precaution to insert a further retention and scrubbing stage before allowing water into the Sanctuary marshlands. If these marshlands are to act as additional scrubbing



*Source: Water Management District No. 6 Study agents, runoff water should be distributed in a natural, uniform pattern over their entire extent. Waters introduced at a few localized points will tend to proceed seaward too rapidly and would not spread laterally in optimum fashion. Consequently, the full extent of the marsh will not be efficiently utilized as a scrubber and buffer for the estuarine regions of the Sanctuary.

A modification of the Interceptor Waterway can be utilized to assist in the achievement of high water quality in this area. There are, however, problems and limitations imposed here. If the waterway is to be maximally efficient it should be in at least tenuous contact with tidal waters. To achieve this it must be connected with (a) tidal creeks leading northeast from Rookery Bay or (b) Henderson Creek.

The establishment of a connection with tidal creeks is possible, but would be extremely unpopular since this would place the waterway within the Sanctuary itself, and would require considerable disruption of Sanctuary lands during its construction. Consequently, this approach cannot be seriously considered.

To place the waterway outside of the Sanctuary boundaries is to place it on the upland margin of a fresh-water marsh. If this is done no connection can be made with Henderson Creek for fear of saltwater intrusion.

Consequently, the waterway, if it is considered at all, will be a fresh-water "hanging lake." We do not consider this an optimum state of affairs, but we believe it is better than nothing. There is, however, a further problem in locating a fresh-water waterway. If it is built in the logical location at the boundary between pine-palmetto and fresh-water sedge marsh, it will be landward of the existing raised powerline grade. Consequently, water flowing over its lower (seaward) margin will be restricted from a broad frontal flow through the Sanctuary. The powerline grade probably cannot be punctured in sufficient locations to permit a sheetflow effect. We are of the opinion that, if built, the waterway should be located just seaward of the power line, which places it in two spots within the corners of the Sanctuary.

Area A: The peninsula of land between Henderson Creek to the north and S.R. 951 to the south poses considerable problems from a planning and management aspect.

From an overall planning standpoint, ignoring for these purposes any announced development plans, an Interceptor Waterway can be efficiently incorporated into this peninsular area. The waterway design criteria would not differ significantly from those outlined elsewhere, but its length or extent would be a variable element. Logically the northern end of the waterway would be the high ridge on which the Shell Island Road is built. The southern end could have a controlled connection to tidal water near S.R. 951 (see Figure 3). Tidal data for Henderson Creek (Lee and Yokel, 1973) indicate that, to function optimally, the waterway should be so situated that its seaward edge is at an elevation between +1.7 and +1.8 feet (M.S.L.). This must be regarded as an approximation since we have no tide gauge records from the specific area. The suggested alignment drawn on Figure 3 is a gross estimate since we do not have accurate information on elevations below the 2-foot contour.

If an Interceptor Waterway were so constructed to receive upland runoff which has previously been retained in upland lakes for preliminary polishing, and could distribute its overflow waters seaward to undisturbed mangrove marshes, we believe that relatively intensive development could be permitted between the waterway and S.R. 951.

SUMMARY

Runoff from Area C1 (see Figure 3), a logical high urban density extension of Naples, should be adequately retained and distributed. One way to achieve this is by use of the Interceptor Waterway as outlined in the text.

Area C5 and the drainage slough on its northern extremity are critical to the ecological health of the Sanctuary. Consideration should be given to a retention and sheetflow distribution system associated with C5.

The Interceptor Waterway system has ecological merit as a water management tool in the land tract south of Henderson Creek and west of S.R. 951.

The Study Team believes that the Interceptor (and Perimeter) Waterway concept is less useful and less essential within Water Management District #6 now than when it was first proposed. The current possibility of large-scale land acquisition, which was not apparent in 1968, relieves to a large extent dependence on man-made water cleansing systems such as the Interceptor Waterway. However, should the Interceptor Waterway become overloaded and exhibit heavy rooted vegetation growth, it can be cleaned out far more easily than an extensive marsh area. The process of deterioration, if it occurs, is also more easily recognized and monitored in an accessible waterbody than in a marsh.

LITERATURE CITED

Conservation Foundation. Rookery Bay Area Project. Washington, D.C. 1968.

Lee, Thomas N., and Bernard J. Yokel. "Hydrologic and Beach Dynamics Studies In and Near Rookery Bay Sanctuary". Conservation Foundation, Washington, D.C. 1973.

Tabb, Durbin C. and Eric J. Heald. "The Coastal Interceptor Waterway". University of Miami Sea Grant Coastal Zone Management Bulletin, No. 4. 1973.

Tabb, Durbin C., Eric J. Heald and Raoul G. Rehrer. "Innovations in Coastal Management". Proc. Gulf Carib. Fish, Inst. 25: 175-180.