A Marine Survey for the Achang Bay Marina

A MARINE SURVEY
FOR THE ACHANG BAY
MARINA

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A MARINE SURVEY FOR THE PROPOSED ACHANG BAY MARINA[1]

INTRODUCTION

Background

In Nov., 1968, Mr. Hugh Fawcett submitted a proposal to the Department of Land Management, Government of Guam, for construction of a small boat marina near Tochog Creek, on Achang Bay (Fig. 1). The proposal involved dredging of tidal and submerged lands located seaward of Lot. No. 273-2-1 within the municipality of Merizo (Fig.2). There was no response to the above proposal by the Dept. of Land Management, so Mr. Fawcett submitted the proposal to the Dept. of Public Works, Division of Highways and Drainage. The proposal was given verbal approval in Sept., 1968, by this agency. Mr. Fawcett, the owner of several pieces of dredging equipment, began the dredging phase of the project in his spare time. Dredging operations were stopped in September, 1971, because Mr. Fawcett had failed to obtain a written permit to dredge in the tidal and submerged waters of Cocos Lagoon.

To obtain the required permit it is now necessary (National Environmental Policy Act, 1970) for Mr. Fawcett to file an Environmental Impact Statement with the U.S. Department of Interior, the U.S. Army Corps of Engineers, and the Government of Guam. He contacted the authors of this report through the Director of the Marine Laboratory, and requested an environmental assessment of the construction site. The results of this survey are contained herein.

This report is based upon drawings by Arizala, Costiniano, and Torres entitled; "Dredging Plan and Proposed Achang Bay Marina, project no. 710-475."

Figures 1, 2, and 4 are from the above project drawings.

This report does not constitute a complete Environmental Impact Statement. Instead it is an environmental impact survey or assessment from which Mr. Fawcett may extract details for his final statement.

The Proposal

The project consists of two parts and is to be completed in several

1/ This work and the opinions contained herein are those of the authors and not necessarily those of the University of Guam, the Marine Laboratory, or the Government of Guam. The project is considered a community service and the work was conducted by the authors on their own time.

phases. Phase one, is the offshore development and features a protected boat basin approximately 80 by 55 meters. This basin will be connected by an access channel to the head of Manell Channel in Cocos Lagoon, (Fig 3). Figure 4 shows the construction details of the access channel causeway. The boat basin is enclosed on the east, west, and south sides by earth and rock causeway-jetty structures. A single earth and rock jetty projects into the basin from the landward side which is to serve for additional boat moorings (Fig.3). The access channel is bordered on both sides by earth and rock causeway-jetties (Fig. 3).

Phase two, consists of the inshore development and is contingent upon completion of phase one. It will include a boat launching ramp, facilities for dry docking and refueling, food and bar service, cold storage facilities, boat and motor repair and maintenance facilities, boat rentals and sales, and fishing charters and tours. All of these facilities , except the boat launching ramp, are to be located above the high water mark and will not be considered further.

Potential modification of the marine environment includes the following:

1) Boat basin and ramp construction will alter the present shoreline.
2) Dredging will physically remove the extant benthic habitat of the lagoon fringing reef flat.
3) Dredge silt may affect downstream benthic organisms.
4) The causeway-jetty structures will cover benthic organisms and habitat of the fringing lagoon reef flat.
5) The causeway-jetties will channel the seaward flow of the Tochog Creek directly to Manell Channel.

RESULTS

Description of the Study Area

General Land Forms and Geology:

The study area is located along the shore of Cocos Lagoon near the west end of Achang Bay (Fig.1). Tochog Creek empties into the head of Achang Bay on the west side and the Manell River empties into the head of the Bay on the east side. Of these two rivers, the Manell River has a much larger drainage basin than Tochog Creek (Fig. 1).

The project site is located on the seaward edge of a low, flat, swampy, alluvial plain. The site is bordered on the east by Tochog Creek, on the north and west by Route 4, and on the south by Achang Bay (Fig 2).

Tochog Creek and valley trends in a northerly direction from its mouth on Achang Bay and originates on the southern flanks of Mt. Finasantos and Mt. Sasalaguan. The sides of the valley consist of steep dissected slopes that make up the lower slopes of the above mountains. Geologically, these mountains and valley slopes are part of the Umatac formation. The rocks of this formation are of volcanic orgin and consist primarily of pillow basalt and tuffaceous sandstone and shale. Most of the rocks making up the slopes of the Tochog Creek valley are deeply weathered and altered into clay.

The alluvial valley floor is quite narrow in the upper part, but the lower part widens into a broad alluvial plain that stretches along the coast from Manell Point to the West to Liguan Point to the East. At present the alluvial valley floor is the site of scattered residential dwellings. Quinene Road follows the west margin of the valley floor to the head of the alluvial plain. Another small road penetrates the alluvial plain on the east side of Tochog Creek and curves toward Quinene Road. These two roadways encircle a broad swampy zone, through which, the Tochog Creek meanders (Fig. 1). At Manell Point a low lying bed of argillaceous limestone of the Mariana formation, interrupts the alluvial coastal plain, west of Tochog Creek.

At the project site the alluvial plain is elevated about one to two feet above mean high tide. The alluvium consists mostly of a dark colored volcanic clay, silt, and a sand fraction. In addition it is rich in organic matter and intermixed with a lesser fraction of calcareous material composed of sand and coral rubble. At most places the upper surface of the shoreline has been raised about a foot by the addition of material previously dredged. This upper layer consists mostly of calcareous sand and coral-algal-rubble, of lagoonal origin, intermixed with dark colored silt and sand of volcanic origin. The alluvial deposits along the entire shoreline of the project site are underlain with limestone which grades into the exposures of Mariana limestone on the west. On the east side of Tochog Creek the alluvium consists of a thin layer of silt, sand and gravel near the highway and grades into a exposed intertidal zone of limestone in a seaward direction. At the present time, the shoreline of Achang Bay is a zone of accretion and supports a rich mangrove community. At the mouth of the creek this mangrove community is interrupted by a zone of mixed vegetation, typical of a disturbed region. There is no mangrove vegetation on the shoreline of the project site at the present time but, mangrove communities flank both sides of it.

Previous Dredging and Other Projected
Construction in the Study Area:

As previously mentioned above this project was partially completed before work was stopped in Sept, 1971. Figure 3 shows the location and extent of dredging and construction activities before work stoppage. These prior activities are as follows:

1) The natural channel of Tochog Creek has been deepened about 1 to 1.5 meters and widened from a point 25 meters south of the bridge on Highway 4 to a point 150 meters seaward.
2) Materials dredged from this stream channel have been used to build two causeways, one 50 meters in length on the East side of the channel and one 105 meters in length on the West side of
3) The boat basin region has been dredged to an area 30 by 50 meters

and the dredge spoil used to construct an earth causeway-jetty 25 meters in length that projects from the shoreward side of the basin. Depth in the boat basin is about 1 to 1.5 meters below the mean lower low water level.

The Director of Public Works, informed the authors of this report that the Government of Guam plans to replace the Route 4 bridge, which crosses Tochog Creek and channelize the creek bed where it passes through the alluvial swamp to the creek mouth at the project site. According to the Dept. of Public Works the creek channel has silted in and causes flooding of residential areas in the valley and an associated mosquito problem, during periods of heavy rainfall. The section of stream bed to be channelized from the bridge to the mouth, coincides with the existing channel that Mr. Fawcett has partially completed.

Physiographic Description of the Marine Zones:

Intertidal Zone

Within the confines of the project site this zone consists of the sloping sides of the causeway-jetty structures and the shoreward side of the boat basin (Fig. 3). All of this region has been disturbed and altered by previous dredging and filling. The dredge material consists of gravel, sand, silt, coral-algal-mollusc-rubble and large intact coral colonies up to a meter or more in diameter.

East of the project site, this zone is restricted to a mangrove community bordering the shoreline (Fig. 5). The substrate in this mangrove community is an irregular limestone platform composed of *in situ* fossil corals of lagoonal origin. Near the stream channel a thin layer of silt, mud, and scattered calcareous fragments covers the platform. Farther away from the channel (eastward) the silt and mud becomes intermixed with a larger fraction of calcareous material. To the west the zone is considerably wider and consists of two parts. A mangrove community occupies the shoreline part of the zone with a substrate similar to that described above for the east side of the creek channel. Seaward of the mangrove community, a section of the lagoon reef flat platform is also exposed during the low tides. Near the creek mouth and channel this platform is composed of dark colored, plastic, mud intermixed with calcareous pieces of coral-algal-mollusc rubble, sand, and gravel. Farther to the west, away from the influence of the creek, the calcareous fraction of the sediments increases. The entire intertidal zone west of the creek mouth and channel is underlain by an older limestone platform similar to that described for the east side of the channel. The general level of this limestone platform is slightly higher than the mean low tide level.

Subtidal Fringing Lagoon Reef Flat Zone

In the immediate area of the project site, the outer part of the access channel, from Sta. 7 to the Manell Channel margin, represents this zone (Fig. 5). The natural stream channel has not been disturbed lagoonward of the existing access channel causeway and is poorly defined except where it grades into Manell Channel. The floor of this reef flat platform consists primarily of dead Portes lutea colonies in position of growth. Relief of these dead corals ranges from 20-50 cm. above a soft mud and silt substrate which is intermixed with calcareous fragments composed primarily of coral-algal-mollusc rubble. The reef flat platform slopes gently from the intertidal zone lagoonward to the margin of Manell Channel where at mean low tide the depth ranges between 30 to 50 cm to the general level of the dead Porites colonies. A living sub-ramose incrustation of coralline algae occupies the upper surface of the dead coral colonies that project through the muddy basal substrate. At some locations these algal incrustations have an aggregate thickness of five or more centimeters. Eel grass, Enhalus acoroides, forms scattered patches interspersed between the coral heads.

Figures 5 and 6 shows the extent of Enhalus on both sides of the access channel and in the immediate study area. The platform in these adjacent locations is quite similar to that described above for the project site, access channel except:

1) the muddy substrate is composed of a larger fraction of calcareous material than that of the stream channel, and
2) the relief of the dead coral colonies, above the mud and calcareous sediment, becomes less in a direction away from both sides of the stream channel toward the mangrove borders, where the tops of the colonies are flush or only a few inches above the sediments.

Lagoon Channel Margin, Slopes, and Floor

The head of Manell Channel originates in the general vicinity of Achang Bay except for a small fingerlike projection to the west (Fig. 1). During high tide, the channel is connected with the main body of Cocos Lagoon by water less than a meter in depth that covers the broad fringing lagoon platform to the west. During lower tides, the channel is isolated from Cocos Lagoon by exposure of the platform. Manell Channel has a small secondary channel which projects landward in the vicinity of the poorly defined Tochog Creek Channel (Fig. 1). This small embayment is probably related to the stream mouth and it's head marks the terminus of the project access channel causeway structures (Fig 3).

At the Manell Channel margin the stream channel slope increases abruptly to 30 or 40 degrees to the 5 to 6 meter depth where it grades into the channel floor. The channel margin and slope, east and west of the stream channel and on the lagoonward side of the channel have a steeper gradients (up to 70°) to the channel floor.

In general, the channel margin and upper slopes along the shoreward side of Manell Channel consist mainly of scattered dead Porites lutea colonies in position of growth and up to a meter or more in diameter. Between the dead colonies the substrate consists of dark colored mud and silt intermixed with light colored bioclastic fragments. The lower channel slopes are similar to the upper slopes except that a larger number of the coral colonies are living and the amount of unconsolidated sediments increases toward the channel floor. The lagoonward side of Manell Channel is similar to the shoreward side except for the density of living coral colonies which increases slightly and the fraction of calcareous material in the substrate composition is greater.

The channel floor near the project site is composed of unconsolidated sediments similar to those found on the slope and margin. The bioclastic fraction of these sediments increases steadily across the channel floor to the opposite side of the channel. The channel floor is relatively flat but locally it is very hummocky due to the burrowing activity of an unidentified marine worm.

Biological Studies

Tables 1 and 2 are a compilation of all the organisms observed and collected in the study area. Figures 5 and 6 show the locations of the various regions of the study area where observations and collections were made.

Intertidal Zone

Few species of organisms were observed in this predominately disturbed zone although fiddler crabs (Genus Uca), two or more species of mud crabs (Xanthidae), the mudskipper fish (Periopthalmus koelreuteri), and small hermit crabs were observed there. The stream channel from Stations 1 to 2 is the least disturbed part of this zone and the same organisms were found there, but in greater densities. The intertidal zone to the east of the project is mostly undisturbed and consists of a mangrove community. The mangrove community forms a band along the shore 15 to 30 meters wide and the outer edge forms the boundary between this zone and the subtidal reef flat platform (Fig. 5). The band is weakly zoned with Rhizophora , the dominant species, forming a wide outer zone facing Achang Bay and Rhizophora intermixed with Bruguiera forming a narrow shoreward zone. Littorinid snails are common on the proproots of the outer band above the high tide level. Fiddler crabs and mud crabs are abundant throughout the zone and wherever soft sediments occur, their burrows honeycomb the substrate. Mudskipper fish and their conspicuously rimmed burrows are found along the outer part of the zone or where intertidal pools persist.

Several species of blue-green algae (Cyanoyhyta) form a thin mat over much of the muddy substrate and rocky surfaces. During high tide, it is common to find thin green sheets of these algae that have broken loose and floated to the surface. Champia forms a narrow band of filamentous algae at about the mean high water mark on the mangrove proproots and rocky surfaces. Oscillatoria forms dense tangled mats near the bridge in the stream channel pools (Stations 1 through 3).

The intertidal zone on the west side of the project site includes a band of mangroves 10 to 20 meters wide plus a considerable section of the fringing reef flat platform (Fig. 5). The community described for the mangrove area on the east side of the project site is essentially the same as that on the west except for being slightly narrower and the presence of a small islet of mangroves at the tip of Manell Point (Fig. 6). The fiddler and mud crab and mudskipper community extends out onto the reef flat platform from the mangrove band. Scattered Enhalus beds are common where the zone grades into the subtidal part of the platform, Dead flat-topped coral heads are numerous in this part of the zone. The upper surface of these heads are covered with a variety of soft benthic species of algae (Table 1). The margins of many of these flat-topped coral heads have a calcareous nodular algae growth (? Porolithon sp. 2) incrusting them. The surface of this growth is yellow in color where exposed directly to the light and a dark purple to greenish-red color at the basal part of the growth, away from direct light exposure. Blue-green algae mats are also abundant on both the coral heads and intervening unconsolidated substrate regions.

Subtidal Fringing Lagoon Reef Flat Zone

At the project site this zone occupies the excavated boat basin area, the partly completed access channel, and the unfinished portion of the access channel to the edge of Manell Channel (Fig 3). This disturbed region has a large community of jellyfish, Cassiopea sp. up to 20 cm or more in diameter, occupying the bottom. They are particularly abundant at the lower intertidal margin of the boat basin area where they form an almost continous band. Very few of these jellyfish were noticed outside of the dredge areas. Boulders left in the dredge areas were nearly always covered with dense growths of Caulerpa racemosa and Halimeda opuntia . Schools of small fish were commonly observed swimming and feeding in the dredged areas. Dense aggregations of the gastropods, Cerithium sp.1 and C. sp.2 form at the intertidal-subtidal interface. No living corals were found in the dredged areas of the project site. This zone east and west of the project site and the stream channel seaward of Station 7 is rather uniform in respect to the biological communities present. In general, the diversity of organisms increases in any direction away from the stream channel and from the intertidal boundary seaward to the margin of Manell Channel.

The entire bottom of this zone consists of dead coral colonies in position of growth. Many of these colonies are a meter or more in diameter. Quantitative analysis of this region showed a surface coverage of nearly 50 percent of these dead corals. The density of dead corals was somewhat less in the poorly defined stream channel, but there was little reduction toward the shoreline. By using a snorkel and face mask and swimming over the region several times, only six living corals were encountered. Of these six corals half were Pocillopora damicornis and half were Porites lutea. All six colonies were less than 10 cm in diameter and found within 20 meters of the Manell Channel margin. The same calcareous nodular algae (? Porolithon sp. 2), that was found on the coral heads in the intertidal zone, was found encrusting the upper parts of the coral heads in this zone.

Enhalus beds are conspicuous along the inner half of the zone on the east side and became the dominant community on the west side toward Manell Channel. Short strands of Sargassium polycystum, and tuffs of Padina minor are abundant on dead coral heads along the subtidal-intertidal boundary. Other organisms occuring in this zone are listed in Table 1.

Manell Channel Margin, Slope, and Floor Zone

Biologically the channel margin and slope zone have a greater species diversity than any other region of the study area (Table 1). Typical reef fish and invertebrates are numerous and living corals are nearly restricted to this region (Table 1).

The region of dead coral heads, described previously for the reef flat zones, continues onto the channel margin and down the upper channel slopes to a depth of 1 to 2 meters. This dead zone extends along the north side of Manell Channel, both eastward of the project site stream channel and westward to the head of the small finger-like embayment (Fig. 6). The head of the small western embayment and the south side of the channel have considerable more living coral growing on the margin and upper slope than the north side, but still, an unusually large percentage of the colonies present, are dead. A similar zone of dead corals was found along the shoreward channel margin and upper slopes in a previous study, located nearby, at the head of Mamaon Channel (Jones and Randall , 1973). The presence of dead corals at the head of Manell Channel predates the early dredging activities at the mouth of Tochog Creek by Mr. Fawcett.

Early in 1968 the senior author of this report made several reconnaissance studies and collected corals from the various zones of Manell Channel. During these earlier observations the same zone of dead corals was noted from the head of Manell Channel, to and including, a small embayment located on the shoreward side of the channel near Balang Point(Fig. 1). The actual cause of the death of these corals is unknown at the present time but it appears to be a periodic phenomenon. In the past, these corals along the head of Manell Channel seem to have developed rather uniformly into a rather dense community of large massive Porites lutea colonies. Many of these coral colonies are over one meter in diameter and have a general subhemispherical growth form, except those growing on the upper margin, which are flat-topped due to their upward growth being limited by the low tide level. A conspicuous feature, on the upper surface, of the large colonies is the presence of many dead secondary colonies, most of which are under 30 -40 cm in diameter. These secondary colonies, inturn, have on their surface the few scattered living patches and knobs of living coral.

It was these knobs and patches that constituted most of the coral growth observed along the upper slopes and margin in this study. It is obvious that the channel margin and upper slope was, at some time in the past, a region with a high density of living _Porites_ colonies. This period was then interrupted by widespread death of most of the living surfaces of these colonies except for a few isolated patches which survived and gave rise to the smaller secondary coral colonies. These secondary colonies thrived and developed into a general size range around about 30 - 40 cm in diameter. Like the parent colonies, these secondary colonies also have been killed except the few scattered knobs and patches recently observed.

The lower margin slopes (below 1-2 meter depth) have good coral growth and development on the south side of the channel but on the north side the coral growth and development is very poor and patchy. The dominant corals are _Porites cocosensis_, _Porites lutea_, _Porites (S.) horizontalata_. _Porites (S.) iwayamaensis_, _Porites (S.) convexa_ , and _Porites (S._) sp. Single line transects showed that coral coverage of the lower channel slopes at Station 17 was less than two percent (north side of Manell Channel), 4.2 percent at Station 18 (north side of west embayment), and 8 percent at Station 19 (south side of Manell Channel). No corals were encountered on the transects on the upper (1-2 meter depth zone) channel slopes and margin, although widely scattered colonies occur there. The coral communities found on the channel margin and slopes were very similar to those found during a similar study at the head of Mamaon Channel (Jones and Randall, 1973).

The channel floor is composed of unconsolidated sediments and is relatively barren compared to the channel slopes. The floor has numerous conical-shaped hummocks produced by the burrowing activities of a marine worm. Gobioid fishes and plants such as _Halimeda opuntia_, _Arrainvillea obscura_, and _Halophila minor_ were the only common organisms encountered on the channel floor.

Table 2 is a checklist of fishes that were observed at four stations located at the head of Manell Channel. Figure 6 shows the locations of the four stations. Turbid water conditions made fish observations impossible over most of the lagoon reef flat platform and in the partially finished boat basin and channel.

Current Patterns

The current patterns presented in this report were conducted over a 24 hour tide cycle. Table 3 shows a summary of the data collected at the project site and adjacent Manell Channel. Figures 5 and 6 show the various current vectors plotted at each station. Current patterns were determined by tracking dye injected into the water mass and drift crosses. In the general region of the partially finished boat basin and access channel (Stations 3-7) there was virtually no current, or if present consisted of a slight movement to the west due to wind influence on the upper few cm of water. On the fringing lagoon reef flat (Stations 7-12) there was a general southwestern current except from 1515 to 1540 (June 8) when the currents showed a weak southern movement (Fig. 5 and Table 3). Currents in Manell Channel (Stations 13-16) had a general westward movement toward the main body of Cocos Lagoon except during the latter part of the ebb tide and the first half of the flood tide from 0120 to 0800 (June 9) (Fig. 6 and Table 3). During this period of time the currents in the channel were moving seaward in a general southeastern direction (Fig. 6 and Table 3).

The unidirectional seaward flowing current found during an earlier study at the head of Mamaon Channel (Randall and Jones , 1972), was not observed during this study at the head of Manell Channel. Instead the predominant current was found to be toward the west lagoonward, at the head of Mannell Channel (Fig. 6).

CONCLUSIONS

1. The intertidal and subtidal communities located near the mouth of the Tochog Creek are, at present, adjusted to seawater dilution and siltation during periods of heavy stream discharge. At other times stream discharge is negligible.
2. Dredging operations will remove approximately 4000 cubic meters of material to deepen the boat basin and access channel. The benthic communities present in intertidal and shallow subtidal regions of the boat basin and access channel will be physically removed by this dredging. The mean lower low water depth in these regions will be minus six feet after dredging. This deeper water habitat will be recolonized by another type of marine community. Both density and diversity of the fish community will probably increase as a result of the deeper water habitat created by dredging.
3. Six thousand cubic meters of dredge material will be used to construct the boat basin jetty, access channel causeways, and boat ramp. Construction of these causeways and jetties will cover 3050 square meters of marine habitat in the area. New intertidal and subtidal rocky habitats will be created by construction of the causeways and jetty. This new habitat will probably become populated by crabs, molluscs and fishes. Mangrove seedlings are, at present, colonizing the east side of the existing access channel. This community can be expected to develop on the border of the remainder of causeways when completed.
4. Dredging operations in the boat basin area (Fig. 5) will increase turbidity and the amount of suspended material in the water mass. It is expected that most of this suspended silt will settle out in the same area of dredging operations because of the lack of well defined currents (Fig. 5 and Table 3). Some of the silt charged water can be expected to move out of the boat basin area during ebb tide or by wind drift and diffusion and be carried away according to the current patterns present on the subtidal lagoon platform and in Manell Channel. The current patterns detected during this study showed that most of the time this plume will move westward over the shallow <u>Enhalus</u> community located

west of the small embayment at the head of Manell Channel (Fig 6.). At times, the dredge plume can be expected to move seaward via the Manell Channel (Fig. 6). Dredging in the access channel region will produce a dredge plume that will drift according to the above described current pattern.

5. Flushing of the basin by tidal action will probably not be sufficient when enclosed by all the proposed causeways. The water exchange in the present partially finished basin is by tidal flushing and seems sufficient, as it supports a large jellyfish population and various species of algae and fish.
6. There will be a deficiency of 2000 cubic meters of dredge material to construct the causeway-jetty structures.

RECOMMENDATIONS

1. Dredge during minus tides or when the predominant current on the subtidal lagoon reef flat and in Manell Channel is toward the west. Do not dredge when a seaward flowing current is present in Manell Channel.

2. The dredge material will contain a large proportion of dead coral colonies which should be used as rip-rap facing on the lagoon side of the east access channel for wave protection.

3. Mangroves should be permitted to colonize the rip-rap facing on the lagoon side of the east causeway for additional stabilization.

4. Remove the west access channel causeway from the south side of the boat basin to the edge of the Manell Channel margin after dredging of the channel is complete. Install conduit pipes in the southwest boat basin jetty. The above two changes will improve the flushing of the boat basin and equalize the amount of dredge material removed and the amount needed for causeway construction.

REFERENCES

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TABLE 1. Checklist of marine organisms in the study area. See Figure 5 and 6 for station locations.

Collecting Stations

ALGAE:

	1-3	3-5	5-7	7-9	9-11	17	18	19	20	21	22	MANGROVES
Acanthophora spicifera											X	
Amphiroa fragilissima					X	X	X	X				
Arrainvillea obscura			X	X	X		X					
Caulerpa filicoides						X	X	X				
C. racemosa		X	X	X	X	X	X	X	X	X	X	
C. sertularioides					X	X	X	X				
C. taxifolia								X				
Champia sp. 1												X
Dictyosphaera cavernosa		X	X	X	X	X	X	X	X	X	X	
Dictyota sp. 1			X	X	X	X	X	X				
Enteromorpha intestinales	X	X										
Galaxaura sp. 1						X	X	X				
Gelidiella acerosa			X	X	X				X	X		
Gracilaria sp. 1		X	X	X	X	X	X	X				
Halimeda gigas					X	X	X	X				
Halimeda macroloba								X				
H. micronesica								X				
H. opuntia		X	X	X	X	X	X	X	X	X	X	
Hormothamnion enteromorphoides	X	X	X	X	X	X	X	X	X	X	X	
Lobophora variegata								X				
Microcoleus lyngbyaceus	X	X	X	X	X	X	X	X	X	X	X	X
Neogoniolithon frutescens											X	
Neomeris annulata				X	X	X	X	X	X	X	X	
Oscillatoria sp. 1	X	X										
Padina minor		X	X	X	X	X	X	X	X	X	X	
Peyssonelia sp. 1						X	X	X				
Porolithon gardineri								X				
? P. sp. 1					X	X	X	X				
? P. sp. 2 (red)		X	X	X	X	X	X	X	X	X		
Schizothrix mexicana		X	X	X	X	X	X	X	X	X		
Spyridia velasqueziii											X	
Sargassum polycystum				X	X	X	X	X	X	X		
Total	4	11	12	14	18	19	20	24	11	11	10	2

TABLE 1. Continued.

	Collecting Stations											
	1-3	3-5	5-7	7-9	9-11	17	18	19	20	21	22	Mangroves
ANGIOSPERMS (marine) :												
Enhalus acoroides			X	X	X				X	X	X	
Halophila minor						X	X	X				
Total			1	1	1	1	1	1	1	1	1	
PROTOZOA:												
Homotrema rubrum						X	X	X	X	X	X	
Marginopora vertebralis				X	X	X	X	X	X	X	X	
Calcarina spengleri						X	X	X	X	X	X	
Total			1	1	3	3	3	3	3	3	3	
PORIFERA:												
Cinachyra australiensis				X	X	X	X	X	X	X	X	
"Sponge" sp. 1									X	X	X	
"Sponge" sp. 2						X	X	X			X	
"Sponge" sp. 3						X	X	X			X	
"Sponge" sp. 4									X	X	X	
"Sponge" sp. 5						X	X	X			X	
Total				1	1	4	4	4	3	3	6	
CNIDARIA:												
Corals												
Acrhelia horrescens						X						
Acropora aspera											X	
A. formosa								X				
Astreopora myriophthalma							X	X				
Galaxea fascicularis							X	X				
Goniastrea retiformis								X				
Heliopora coerulea								X				
Lobophyllia corymbosa								X				
Montipora lobulata						X	X	X				
M. ehrenbergii						X	X	X				
M. granulosa							X	X				

TABLE 1. Continued.

	Collecting Stations											
	1-3	3-5	5-7	7-9	9-11	17	18	19	20	21	22	Mangroves
M. hoffmeisteri						X	X	X				
M. patula								X				
M. verilli							X	X				
Pocillopora damicornis						X	X	X	X	X	X	
Porites andrewsi						X	X	X				
P. cocosensis						X	X	X				
P. lobata						X	X	X				
P. lutea						X	X	X	X	X	X	
P. (Synaraea) convexa						X	X	X				
P. (Synaraea) horizontalata						X	X	X				
P. (Synaraea) iwayamaensis						X	X	X				
P. (Synaraea) sp.1						X	X	X				
Plerogyra sinuosa							X					
Psammocora contigua							X					
Seriatopora hystrix						X	X	X				
Total						13	20	22	2	2	2	
Alcyonacea:												
Sarcophyton sp. 1						X	X	X			X	
Total						1	1	11			1	
Scyphozoa:												
Cassiopea sp.1	X	X	X	X								
Total	1	1	1	1								
"Hydroid" sp.1						X	X	X				
Total						1	1	1				
ANNELIDA:												
Sabellastarte sp. 1						X	X	X		X		
Spirobranchus sp. 1						X	X	X		X		
Total						2	2	2		2		

TABLE 1. Continued

	Collecting Stations											
	1-3	3-5	5-7	7-9	9-11	17	18	19	20	21	22	Mangroves
MOLLUSCA:												
Bursa sp.1									X	X	X	
Cerithium sp.1	X	X	X	X	X				X	X	X	
C. sp. 2	X	X	X	X	X	X	X	X	X	X	X	X
Conus pulicarius									X	XX	X	
Coralliophila violatea							X	X				
Cypraea erosa									X	X	XX	
C. moneta					X	X	X	X	X	X	XX	
Littorina sp. 1												X
Mitra stictica							X		X			
Oliva erythrostoma				X								
"Opisthobranchia" sp.1				X	X				X	X	X	
"Opisthobranchia" sp.2				X	X				X	X	X	
Terebra maculata						X	X	X				
Tridacna maxima								X				
"Vermetidae" sp.1						X	X	X				
Total	2	2	2	5	5	4	6	6	9	8	8	2
CRUSTACEA:												
Amphipoda:												
"Amphipod" sp. 1	X	X	X	X	X				X	X	X	X
Total	1	1	1	1	1				1	1	1	1
Decapoda:												
"Portinid"					X				X	X	X	
"Grapsid" sp. 1	X	X	X	X					X	X	X	X
"Grapsid" sp. 2	X	X	X	X						X		X
Uca sp. 1	X	X	X	X					X	X	X	X
Total	3	3	3	3	1				3	4	3	3
ECTOPROCTA:												
"Brypzoa" sp. 1						X	X	X				
Total						1	1	1				

TABLE 1. Continued.

	Collecting Stations											
	1-3	3-5	5-7	7-9	9-11	17	18	19	20	21	22	Mangroves
ECHINODERMATA:												
Echinometra mathaei								X			X	
Echinothrix diadema								X				
Holothuria argus								X				
H. atra							X	X	X	X	X	
H. sp. 1							X	X				
H. sp. 2						X	X	X				
Opheodesoma godeffroyi											X	
"Ophiuroid" sp. 1								X	X		X	
Stichopus chloronotus								X			X	
S. sp. 1								X			X	
Total						1	3	9	2	1	6	

Table 2. Checklist of fishes from the study area. See Figure 6 for station locations

	Stations			
	A	B	C	D
Acanthurus nigrofuscus	X	X	X	
A. xanthopterus		X	X	X
Naso unicornis				X
Zebrasoma flavescens				X
Z. veliferum		X		
Apogon leptacanthus		X		X
A. trimaculatus				X
A. robustus	X			
A. sp.				X
Cheilodipterus macrodon		X		
C. quinquelineata	X	X		X
Meiacanthus atrodorsalis		X	X	
Canthigaster solandri				X
Chaetodon auriga			X	
C. ephippium		X		
C. falcula		X		
C. trifasciatus	X	X		X
Heniochus varius	X			
Acentrogobius belissimus	X	X		X
Amblygobius albimaculatus			X	X
A. sp.	X	X	X	X
Gnatholepis deltoides			X	X
Eviota prasites	X	X	X	X
E. sp.		X	X	
Obtortiophagus koumansi			X	
Holocentrus sammara		X		X
Myripristis multiradiatus		X		X
M. sp.		X		X
Cirrhilabrus temmincki	X		X	
Cheilinus fasciatus		X		X
Epibulus insidiatior				X
Gomphosus varius		X		
Halichoeres margaritaceous	X			
H. sp.				X
Stethojulis axillaris			X	
S. sp.				X
Thalassoma hardwickei		X	X	
T. sp.		X		
Lavroides dimidiatus	X	X	X	X
Lutjanus vaigiensis		X		X
Parupeneus pleurostigma				X
P. barberinus				X
Abudefduf lacrymatus			X	
Chromis caeruleus	X	X	X	
Dascyllus aruanus	X	X	X	X
Pomacentrus pavo		X	X	
P. lividus		X	X	

Table 2. Cont.

	A	B	C	D
Pomacentrus sp.	X		X	
Scarus sordidus	X	X	X	X
Siganus punctatus				X
Corythoichthys intestinalis				X
Zanclus cornutus		X	X	X

TABLE 3. Summary of current data. NM = no dye movement, diffusion only ; W = dye movement at surface only by wind; (.2m) = 20 cm drift cross, (1m) = 1 meter drift cross, and (5m) = 5 meter drift cross.

Date	Station Location	Time	Magnetic Bearing	Speed in Knots	Wind Direction	Wind Speed Knots.	Tide
June 8	7	1300	299	.058	094	10-15	ebb
"	8	1302	227	.065	"	"	"
"	9	1306	225	.043	"	"	"
"	10	1309	205	.031	"	"	"
"	11	1311	206	.024	"	"	"
"	12	1314	209	.040	"	"	"
"	13	1319	210	--	"	"	"
"	14	1324	300	--	"	"	"
"	15	1331	290	--	"	"	"
"	16	1340	301	--	"	"	"
"	3a	1312	NM	--	"	"	"
"	3b	1312	NM	--	"	"	"
"	3c	1312	NM	--	"	"	"
"	5a	1315	210W	--	"	"	"
"	5b	1315	208W	--	"	"	"
"	6a	1316	210W	--	"	"	"
"	6b	1316	210W	--	"	"	"
"	7	1530	NM	--	083	10-12	ebb/flood
"	8	1531	174	slight	083	"	"
"	9	1532	179	.013	"	"	"
"	10	1525	181	.019	"	"	"
"	11	1520	162	.019	"	"	"
"	12	1515	178	.039	"	"	"
"	13	1505	308	.026	"	"	"
"	14	1455	298	.029	"	"	"
"	15	1450	305	--	"	"	"
"	16	1445	298	--	"	"	"
"	13(1m)	1505	326	--	"	"	"
"	14(5m)	1455	280	--	"	"	"
"	13	1705	320	.058	074	8-10	flood
"	14	1700	317	.072	"	"	"

TABLE 3. Continued.

Date	Station Location	Time	Magnetic Bearing	Speed in Knots	Wind Direction	Wind Speed Knots.	Tide
June 8	3a	1720	NM	--	074	8-10	Flood
"	3b	1721	NM	--	"	"	"
"	3c	1722	NM	--	"	"	"
"	4a	1725	NM	--	"	"	"
"	4b	1727	NM	--	"	"	"
"	14(1m)	1900	260	Grounded	"	5-7	"
"	14(5m)	1900	270	"	"	"	"
"	12(.2m)	2150	260		"	"	Flood ebb
"	14(1m)	2145	263	Grounded	"	"	"
"	14(5m)	2145	275	"	"	"	"
June 9	14(5m)	0120	162	--	"	"	ebb
"	14(1m)	0230	155	--	"	"	"
"	9	0630	250W	--	065	0-5	Flood
"	10	0631	250W	--	"	"	"
"	11	0632	250W	--	"	"	"
"	12	0633	240	.026	"	"	"
"	13	0634	278	.032	"	"	"
"	14	0635	122	.032	"	"	"
"	14(1m)	0635	122	--	"	"	"
"	14(5m)	0635	122	Grounded	""	"	"
"	3a	1000	NM	--	070	5-10	"
"	3b	1000	NM	--	"	"	"
"	3c	1001	NM	--	"	"	"
"	4a	1001	NM	--	"	"	"
"	4b	1002	NM	--	"	"	"
"	5a	1002	NM	--	"	"	"
"	5b	1003	NM	--	"	"	"
"	6a	1003	NM	--	"	"	"
"	6b	1004	NM	--	"	"	"
"	7	1004	225	Slight	"	"	"
"	8	1005	210	"	"	"	"
"	9	1007	222	"	"	"	"
"	10	1008	217	"	"	"	"
"	11	1009	221	"	"	"	"
"	14	1010	260	Grounded			

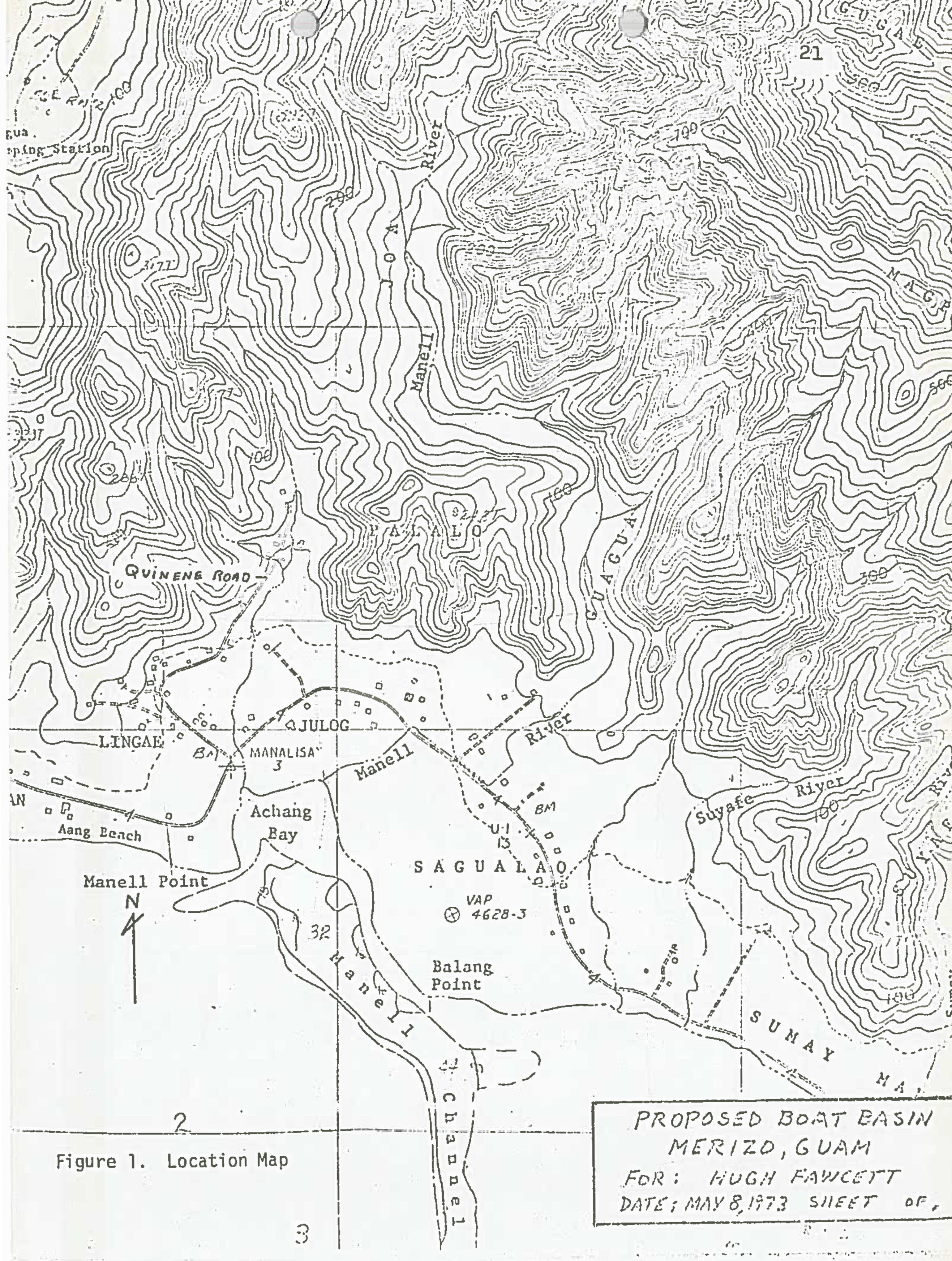


Figure 1. Location Map

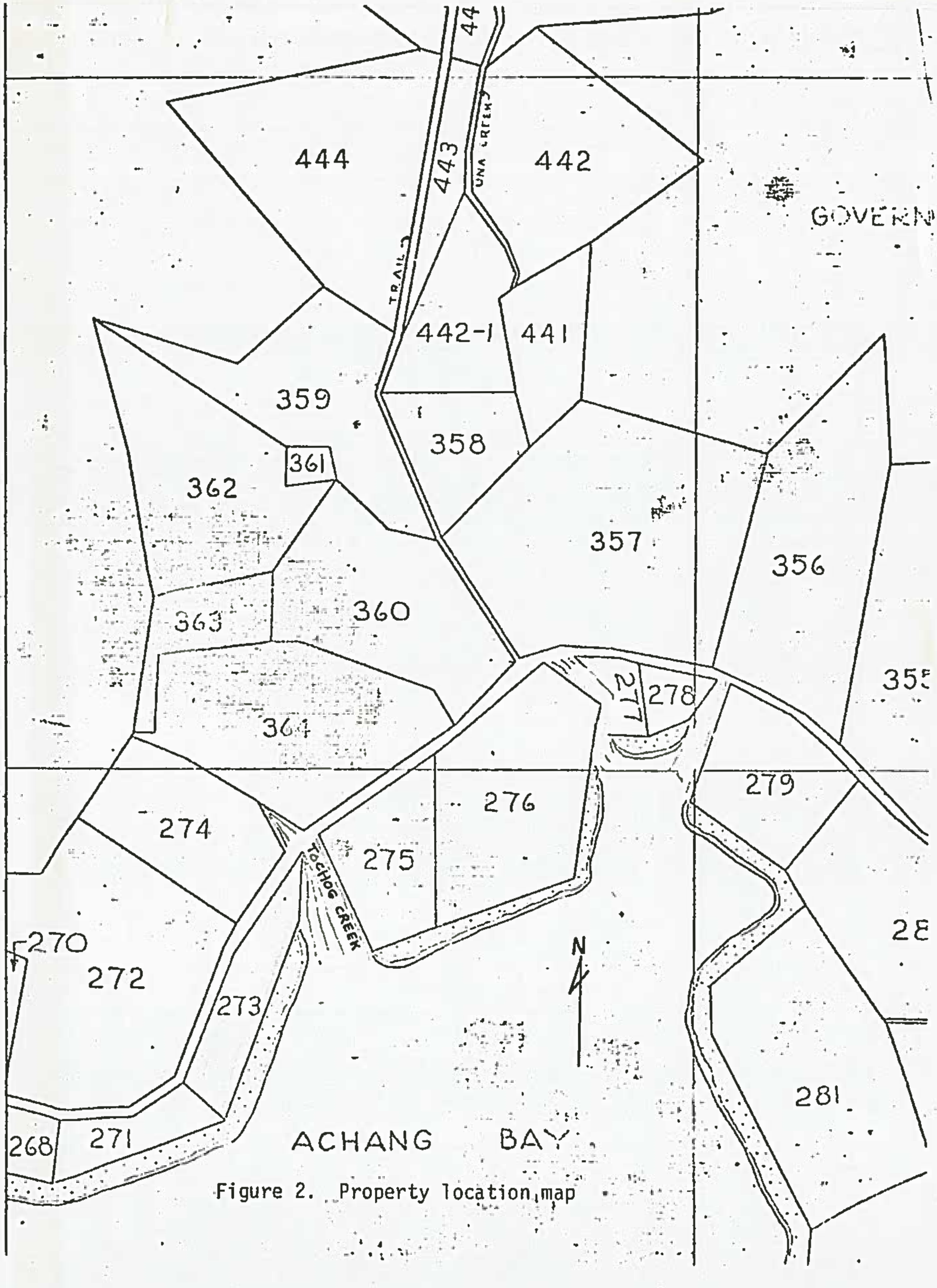
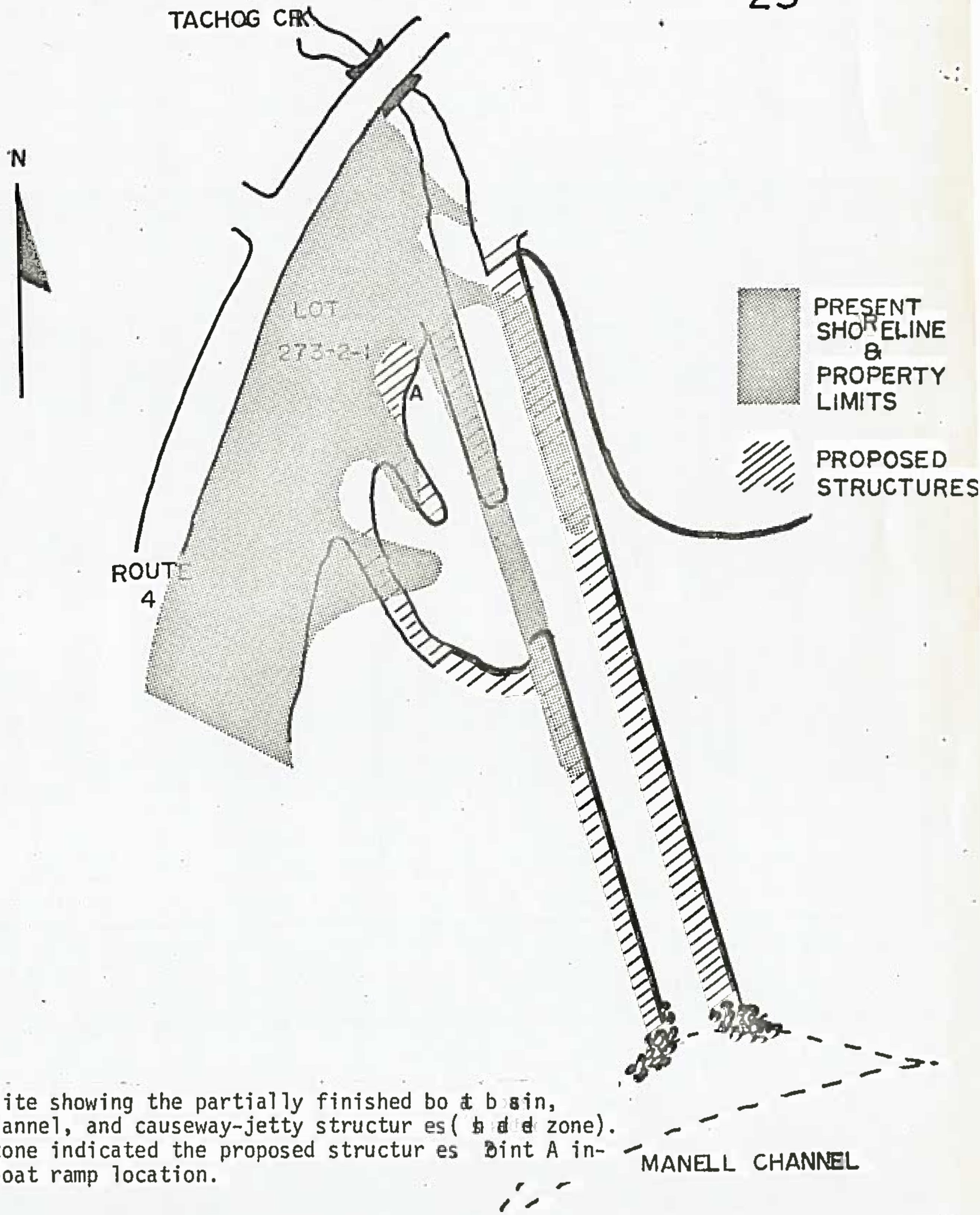
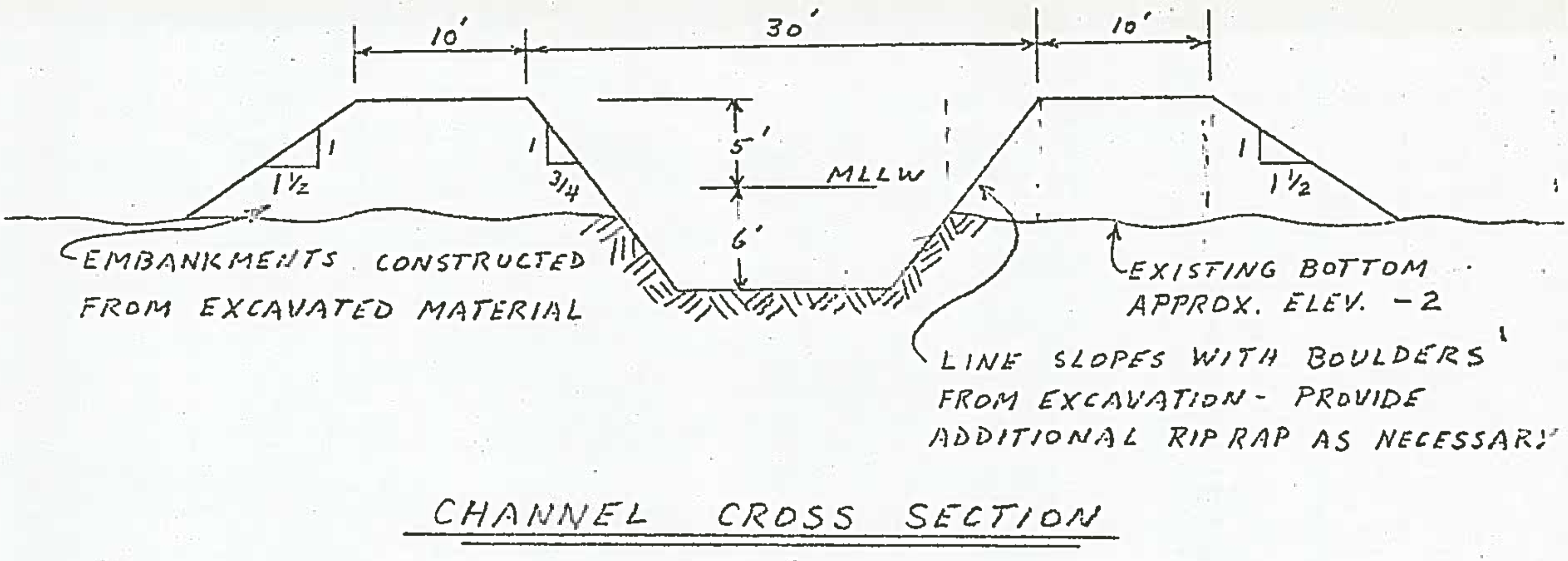


Figure 2. Property location map

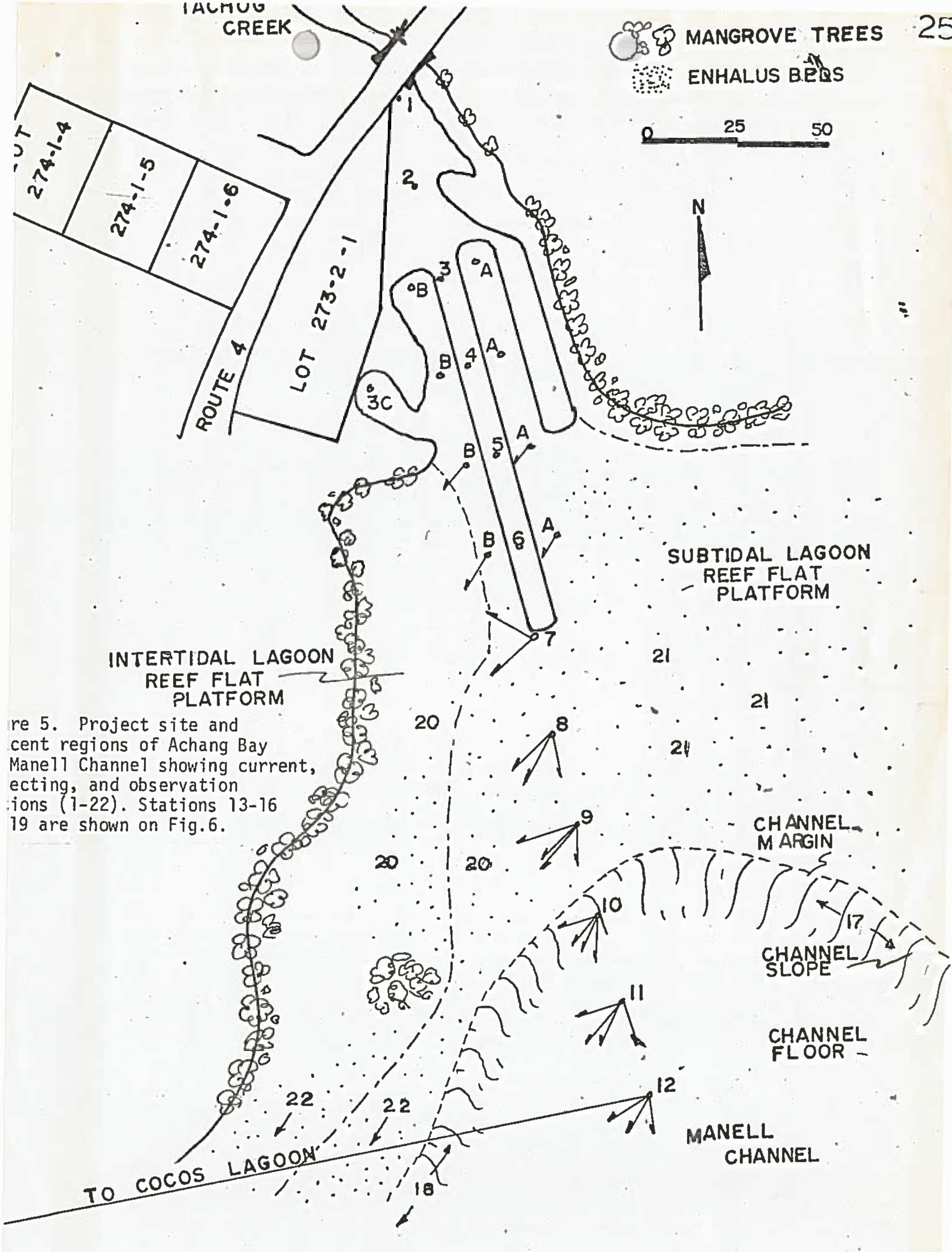


e 3. Project site showing the partially finished boat basin, access channel, and causeway-jetty structures (shaded zone). Slashed zone indicated the proposed structures. Point A indicates boat ramp location.



PROPOSED BOAT BASIN
MERIZO, GUAM
FOR: HUGH FAWCETT
DATE: MAY 8, 1973 SHEET OF

Figure 4. Construction details of access channel causeways



re 5. Project site and
cent regions of Achang Bay
Manell Channel showing current,
ecting, and observation
ions (1-22). Stations 13-16
19 are shown on Fig.6.

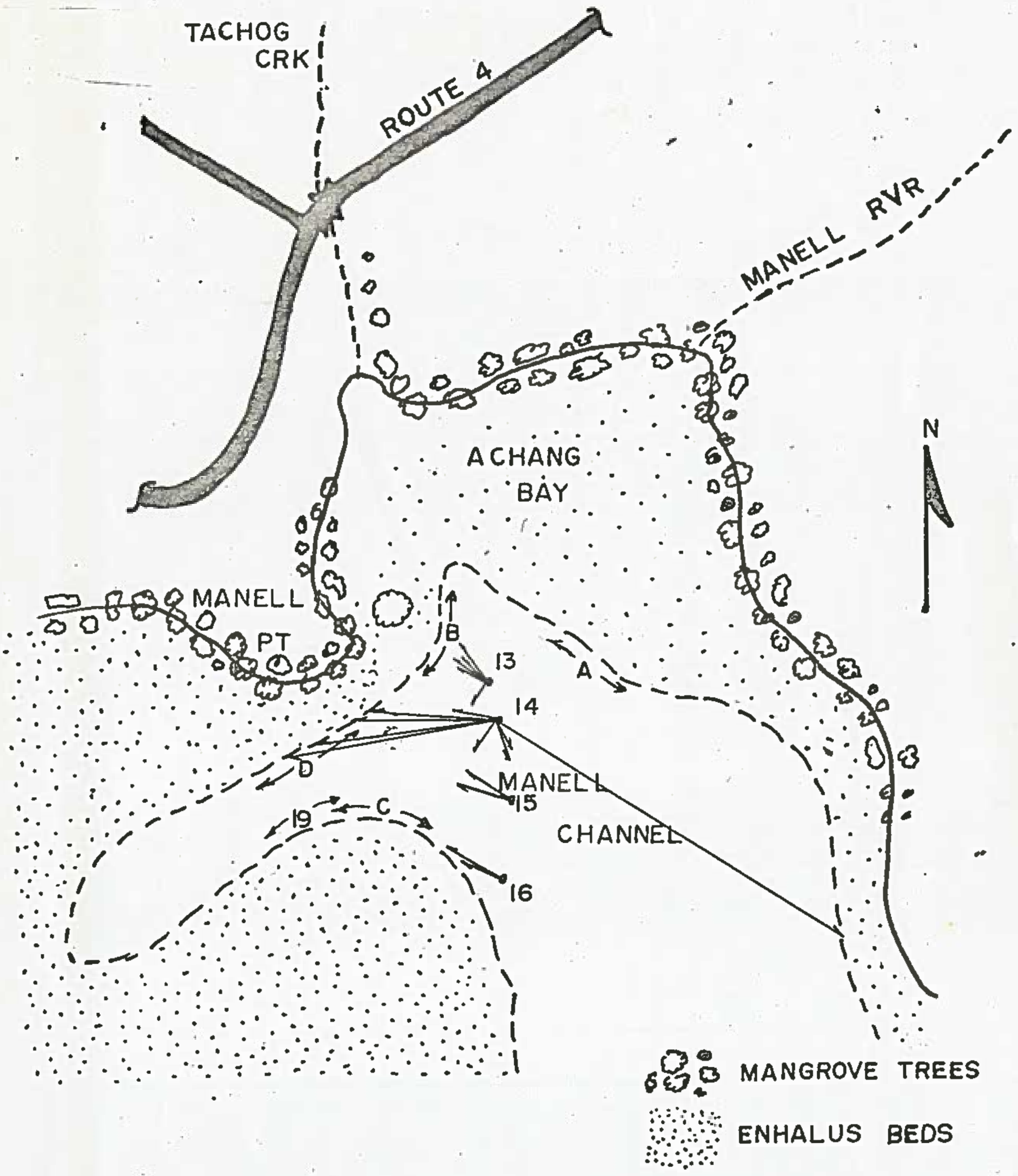


Figure 6. Project site and adjacent regions of Achang Bay and Manell Channel showing, current, collecting and observations stations (13-16 and 19). Fish observation stations are located at stations A-D.