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BALANCE HYDROLOGICS
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(CORNER OF SOLANO AVE.)
BERKELEY, CA 94707

COASTSIDE COUNTY WATER DISTRICT

ENVIRONMENTAL STUDY OF THE PILLAR PT. MARSH, SAN MATEO COUNTY, CALIFORNIA

PART I. BASELINE DATA

February, 1977

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SUMMARY OF BASE LINE-STUDY RESULTS

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1. The Pillar Pt. Marsh has already suffered substantial environmental impacts from earlier acts of man. The construction of the access road to Pillar Pt. through the marsh divided it clearly into freshwater and saltwater sections. Previously, the saline influence had been felt some distance uphill of the location of the road; however, the elevation of the present culvert prevents even the highest tides from passing through.

2. With the upper part and majority of the marsh area free of surface salinity intrusion, the hydrologic problem of the marsh has now become one of whether or not the freshwater section will contract in size or even totally dry up and convert to terrestrial type ecosystems. Since our initial evaluation of the marsh, we have shifted our emphasis to studying chiefly the freshwater section, based on the above facts.

3. The second alteration of the marsh occurred with the construction of the Pillar Pt. Breakwater by the U. S. Army Corps of Engineers. The breakwater effectively stopped the normal ocean wave action which opened up the beach bar each winter and closed it each summer. Currently the bar remains partially breached, with the result that tides can enter only at the higher levels, but throughout the year. Consequently, the lower marsh tends to maintain a rather uniform brackish state throughout the year now, rather than undergoing the natural seasonal shift from saline to freshwater conditions of earlier years. The recent conditions have favored Pickleweed, which dominates the saltwater section, with consequent reduction in species and habitat diversity.

4. An examination of the data of Lowney-Kaldveer (1974) and the recent water table monitoring data of the District leads us to the general conclusion that both the physiography of the groundwater basin and the normally excellent water supply from the Denniston Creek watershed provide the marsh with a very adequate supply of groundwater in normal or wet years. In such cases, it appears from the hydrologic data that pumping up to the 400 AF annual limit on District wells should have little or no effect on the marsh. The marsh is particularly favored by being located in a fault zone into which much of the groundwater drains laterally and then must flow sidewise, i. e., along the length of the marsh, to the ocean, being blocked by the fault scarp of the Pillar Pt. ridge.

The crucial question is, what effect will the pumping have on the marsh during dry periods of a year or longer. We distinctly have the opportunity to find out some kind of answer to that question during the next year or two. The present drought, however, also creates problems for the study. It distorts the data presented here very much toward the dry side from the normal hydrologic year. It may be difficult to separate out the effects of pumping a relatively small fraction of the total annual water supply from those effects created by nature herself under these extreme conditions. We can only hope to follow enough clues so as to find some meaningful ones.

5. Even in this very dry one and a half years, the first real rains (Dec. 31 - Jan. 2) produced standing water in the freshwater section of the marsh up to the 6 ft. contour, about as high as the level usually gets for the majority of the wet period, according to the existing vegetation. Even though no more rain fell for the next month and a half, this level maintained itself and has even increased slightly, indicating that groundwater transmission to and supply for the marsh is quite good. The pre-rain water table in the center of the marsh was greater than 2 ft. (the limit of our auger holes at the time), but is maintaining itself over much of the marsh presently at 1 ft. or less. Important data still needed is the length of time during the year that standing water or very moist conditions occur in various parts of the marsh. We are now placing additional emphasis on monitoring the water table wherever possible around the marsh.

6. There is some evidence that the marsh area may be rising above sea level at a rather rapid rate. If this is so, the saltwater section will convert to freshwater, and over a long period of time, less water would reach the marsh as the drainage patterns become altered. Further data search is called for on this problem.

7. The vegetation of the freshwater section has expectedly shown a shift from brackish to freshwater communities. There is also a heavy invasion of the wet areas by drier habitat species, notably by some of the weedy plants introduced during the construction of the airport, but also by the very aggressive Stinging Nettle (Urtica holosericea). Whether or not these invasions are entirely the result of the drought or reflect some impacts of man is yet to be determined. Reduced salinity and drying of the surface can both be expected to favor expansion of the already extensive stands of willows, but this is a slow gradual process not so easily observed. The present vegetation of the upper marsh classifies it as an intermittent freshwater marsh. In all but the very wet years, most or all of the marsh dries up for a period of time.

8. From past studies, the marsh rather clearly supports a great variety of birds, considerable insects and invertebrates, and a reasonable amount of amphibian, reptilian, and mammalian life in normal years. The populations of many species are very low this year, even as compared to last year (already a dry year), but some species appear to be as populous or even increasing. The numbers of the basic herbivores, i. e., the California Vole and White-footed Deer Mouse, have dropped so low that the raptorial birds are suffering considerably. The shrews, a good indicator of moisture conditions, appear to have been decimated. On the other hand, adaptable species such as the Brush Rabbit, and well-established ones, like the woodrat in the willows, are carrying on "business as usual". The migratory bird populations, including the ducks, other

waterfowl, and warblers, are exceedingly low this year, probably due to the widespread nature of the drought. However, a number of the resident species of the freshwater marsh are doing well, including the Long-billed Marsh Wren, Common Yellowthroat, White-crowned and Song Sparrows, and the Red-winged and Brewer's Blackbirds. Reptiles and amphibians have expectedly been suffering. Only the Coast Garter Snake and the Tree Frog are in evidence.

9. The marsh has not been positively shown to be the residence of the endangered San Francisco Garter Snake, although the snake might be a winter visitant in wet years. The endangered Peregrine Falcon was sighted briefly in 1975. The rare California Black Rail has not been found at the marsh so far, although it is known to inhabit other coastal marshes of the county, and presumably can be present. Some 14 species of birds on the Blue List (species suffering population declines) were sighted last year, but only 5 of these species were seen in 1976. It has been encouraging, however, that of these 5 the American Kestrel, Loggerhead Shrike, and Bewick's Wren were all abundant, and at least one female Marsh Hawk was evident most of the time.

This summarizes the condition of the marsh in a drought period prior to pumping on any of the new District wells.

INTRODUCTION

Background of the Pillar Pt. Marsh Environmental Study

The Coastside County Water District serves the coastal area of San Mateo County from the Town of Princeton at Half Moon Bay on the north to the southern limits of the Town of Half Moon Bay. The Pillar Pt. Marsh lies on the west shoreline of Half Moon Bay downslope of and adjacent to the area in which the District is developing its water supply. The District has undertaken the development of the Denniston Creek watershed as a local supply in a two phase project. Phase I, completed in 1971, concerned itself with utilization of the surface water. Phase II concerns the development of the groundwater resource and diversion of San Vicente Cr. The initial part of Phase II involved the drilling of seven wells along or near Denniston Cr. on its alluvial fan (wells W1-W7, Figure 1). These wells went into operation in 1975. In connection with this part of the project, the District had a groundwater investigation conducted by Lowney-Kaldveer Associates (1974), and an environmental impact report (EIR) for Phase II of the project prepared by Lampman and Associates (1975).

As a second part of Phase II, the District proposes to drill an additional eight wells in the Denniston Creek and airport areas (wells P1-P8, Fig. 1). The groundwater basin for the wells lies in the Coastal Zone under regulation of the Central Coast Regional Commission, to which the District made application for a permit. The latter was granted (CCRC, 1976) with certain conditions attached. In granting the permit, the Commission found that "The proposed water supply project is necessary to meet the short-term needs....." and "is of a limited scale and supply potential, based on available studies of the groundwater basin....." The findings continue, "In its investigations of potential water supply, and in the proposed project, applicant has reflected the principles of comunctive management of surface and groundwaters expressed in findings and policies of the Coastal Plan," and that "the proposed project would not irreversibly commit the groundwater resource to domestic use, particularly if other supplies such as reclaimed wastewater are maximized," and that "as conditioned, the project would contribute data needed to prepare and implement comprehensive management of the water resource."

The Commission further found that "The proposed project could potentially reduce groundwater inflow to Princeton (Pillar Pt.) Marsh, a significant coastal wetland which provides known habitat for an endangered reptilian species (San Francisco Garter Snake) as well as numerous birds and plants. Based on recent groundwater basin investigations available, the project would appear to be developable without adversely affecting the viability of the marsh. However, since the amount of water pumped, rather than the number of wells or length of pipeline, bears the direct relationship to impacts on the marsh, conditions are required to ensure that the project is consistent with Public Resources Code Sections 27001 and 27302, particularly "to preserve the ecological balance of the coastal zone" and "the continued existence of optimum populations of all species of living organisms."

The first condition placed on the permit, and the basis for this study, is as follows, "Applicant shall, prior to initiation of production in any of the proposed wells, adopt a monitoring program for groundwater levels and quality, and biological effects in the Princeton marsh area. Such program shall be developed in conjunction with Commission staff, and staffs of appropriate San Mateo County departments and the California Department of Fish and Game, and shall be submitted for staff approval within 45 days of issuance of this permit. The program shall include development of 1976-77 baseline information, not-less-than bimonthly samples of water quality and biota, and a requirement that results be transmitted to DFG, the Commission, and the County Parks and Recreation Department. The reports shall compare amounts of water pumped from the applicant's Airport area and Denniston area wells (listed separately) to observed effects. Each agency listed above shall make an independent evaluation of the reports, and may conclude that well production is adversely affecting Princeton Marsh. Upon receipt of such conclusion from any two of the three agencies, or from the Commission if the other agencies have not reviewed the report within 30 days of mailing, applicant shall immediately cease production from all Airport wells. Monitoring shall continue, and production may resume with concurrence of the reviewing agencies at any time after one regular monitoring report has been submitted."

The second condition specified that "This permit does not approve any withdrawal of groundwater from a combination of the proposed wells and other District-controlled wells of more than 130 million gallons (400 acre-feet) in any 12-month period. Any request for greater withdrawal shall require approval by the Commission, and must be accompanied by appropriate supporting technical reports."

In order to meet the first condition, the District gave the resposibility of monitoring groundwater to its District Engineer, and of monitoring the biota to the present consultant. The consultant was asked to submit a proposal (Flint, 1976) in two parts as follows: (1) a baseline study to be completed before onset of the rainy season, and (2) a monitoring program to continue as long as is necessary. The proposal was accepted by the District on November 9, 1977, and work was started immediately.

At the same time that the District was developing its local water supply, the Parks and Recreation Department of San Mateo County was planning to expand its Fitzgerald Marine Reserve, which lies along the coastline immediately westward of the area in question. The County's intent is to add approximately 195 acres of coastal bluffs and upland for the purpose of providing public access, the establishment of related park facilities, and the preservation of important natural resources. Amongst the latter is the Pillar Pt. Marsh. The map in Fig. 2

shows the proposed acquisitions for the reserve, and those for the airport expansion as well. Essentially all of the marsh area would be acquired. Acquisition funds for the project have been included in the 1975/76 budget in the amount of $735,000, which represents the first phase. The remaining funds are programmed for the 1977/83 period and are part of the ten-year acquisition and development plan for the Department of Parks and Recreation. Part of the Coast Commission's concern regarding the marsh was based on the fact that the County intended to preserve the marsh. It is our understanding that the County will be acquiring the marsh area quite soon. At present, the property lies chiefly in the ownership of a private individual, but is under the control of Doelger Properties, Inc. The right-of-way of the Pillar Pt. access road, which cuts across the middle of the marsh, is part of the parcel of property on the adjacent ridgetop, which, together with a second parcel on top of Pillar Pt. proper, is leased by the U. S. Air Force for its missile tracking station. A Final EIR (1976) has been issued by the County for the proposed acquisition.

The above are the two principal proposed projects which are germane to the marshland. Several others, however, should be mentioned. The County of San Mateo also has plans for expanding the Half Moon Bay Airport. This matter is presently under study, and one alternative being considered is the expansion of the airport so that it is contiguous with the proposed marine reserve acquisition. We may note at this point that, within the limits of accuracy of the map (Fig. 2), it appears that the proposed boundary between the reserve and the future airport on the eastern edge of the marsh may not include all of the latter. The bayfront of the marsh area is under the control of the Pillar Pt. Harbor District, which has a development project in the planning stage. This project, having been substantially modified recently, will now require a new EIR. The Granada Sanitary District, which currently operates its treatment plant at the north end of the marsh, is proposing to expand its capability by relocation and expansion of the former. The new site is within the immediate area.

Purpose and Approach of the Study

The purpose of this study, as already given above in the charge to the District by the Commission, is as follows:

1. To provide 1976-77 baseline data on the biota of the marsh.

2. To monitor the marsh biota on at least a bi-monthly basis.

3. To make regular progress reports, including a correlation of the monitored data on biota and groundwater.

There is a problem concerning the collection of baseline data. The term "baseline" usually means a norm which can be used as a reference for measuring perturbations in a system. For any factor such as precipitation, which can vary widely from year to year, and particularly in the present dry spell, one must obtain data on its effects for a number of years in order to establish a baseline. Within a period of one or two years, the task is difficult if not impossible, and the data from 1976-77 will obviously be extreme. Thus, inorder to try to get some meaningful results in the shortest possible time, we are placing rather heavy emphasis on the measurement of groundwater and soil moisture levels throughout the marsh in order to be able to observe most directly the response to pumping. In this aspect of the work we are cooperating in every way possible with the District Engineer, who is monitoring the groundwater levels and quality upslope of the marsh. In the biotic realm we are focussing on those organisms which appear to give the clearest and most rapid response to changes in the general moisture regime. The main emphasis here is placed on observing vegetational boundary movements and physiological changes in the key species. The plant species we are presently concentrating on are Water Hemlock (*Cicuta Douglasii*), Swamp Knotweed (*Polygonum coccineum*), and Coast Nettle (*Urtica californica*) although all important species are being measured along the transects. In the animal kingdom we are concentrating on amphibians, reptiles, identifiable soil invertebrates, and certain birds and mammals. Of the latter, only certain insectivorous birds and mammals, notably the shrews, are being studied quantitatively. We are still in the process of determining which species are the best indicators in this particular habitat.

Hopefully the present two-year drought will give a more extreme indication as to the effect of removal of groundwater, assuming that the wells will be at all productive during this coming year. A possible advantage of studying the effect of wells is that if only one or two are functioning, one can try to distinguish the local effects of a given well. In such a fashion, a water project can yield valuable information concerning the natural water regime. We also consider that a thorough understanding of the source of supply of water and of its mode of transmission to the marsh, beyond that already developed by Lowney-Kaldveer, is important toward understanding the operation of the marsh. It would also be desirable to have a better understanding of the environmental characteristics of the entire watershed, since the latter information would be useful with regard to the beneficial uses of water for human needs as well as for the environment. All things considered, we hope to be able to give a reasonable estimate of the effect of groundwater removal on the marsh at the end of one to two years.

GENERAL ENVIRONMENTAL SETTING

Physiographic Setting

The Pillar Pt. Marsh is located on the northwest edge of Half Moon Bay about ½ mi. west of the Town of Princeton and immediately south of the center of the Half Moon Bay Airport in San Mateo County, California. The marsh area is bounded by the bay to the south, Stanford Ave. of the defunct Princeton-by-the-Sea subdivision on the southeast, nearby Airport St. and the airport on the northeast, the service road to the Granada Sanitary District treatment plant on the north, the Seal Cove Fault and the ridge immediately west of it on the west, and Pillar Pt. Military Reservation (USAF Missile Tracking Station) on Pillar Pt. to the southwest.(Fig. 1).

The marsh lies in the Seal Cove Fault Zone which runs from Seal Cove on the northwest to the marsh on the southeast, while traversing the Pillar Pt. headland (Fig. 3). The fault zone borders the southwestern edge of the old beach terrace upon which the airport is situated. Behind the terrace to the northeast lie the buttressed ridges of Montara Mountain. The part of the terrace of concern here is generally bounded on the north by San Vicente Cr. and on the south by Denniston Cr. This portion of the terrace and its overlying alluvial fans slopes gently westward toward the fault zone and southward toward the bay. Behind the Pillar Pt. ridge (a fault scarp) to the west lies the surf zone of the Pacific Ocean, while to the south the Pillar Pt. Harbor section of Half Moon Bay is relatively free of wave action behind the Pillar Pt. Breakwater.

The marsh occupies approximately 66 acres total area. The access road to Pillar Pt., cutting across the marsh in the shape of a horseshoe, essentially separates the saltwater marsh (southern part) from the freshwater marsh (northern part), the two sections being connected by a culvert. The former area occupies about 22 acres, with a small central lagoon connected to the bay by a slough. This portion of the marsh is generally separated from the bay by a beach bar which is breached by the highest tides and partially opened at the slough. The freshwater portion of 44 acres has roughly two arms or lobes. The longer one extends northwestward up the fault zone approximately as far as the sewage treatment plant. The broader shorter lobe extends northeastward toward the toe of the airport runway, from which direction it recieves surface runoff from the airport drainage ditch. A drainage ditch along the upper part of the fault zone empties into the former arm of the marsh at its north end.

Brief History of Land Use of the Marsh Area

The first historical reference to the marsh, of which we are aware, is a topographic map (USC&GS, 1866) which depicts the marsh as a lagoon connected to the bay. All of the surrounding lands on the terrace to the east are labelled "Grain Fields", and various farm roads wander freely across the landscape, including one along the beach bar to Pillar Pt. It is interesting to note that this map also shows a smaller lagoon at the mouth of Denniston Cr. The next reference is an aerial photo (Whittier, 1931) which shows the marsh inundated to at least the extent shown on the earlier map. A bridge has been thrown across the area at the same location as the present road and culvert. The entire surrounding area is given over to agriculture, including the defunct subdivision.

Just after the 1906 earthquake, like all of the other north county coastal towns, Princeton suffered the invasion of land speculators and subdivision - and a very classy subdivision it was to be with streets all named after our finest colleges. That never-to-be-realized, idyllic sea community has left its imprint in the street pattern, and the map location of its waterfront "Ocean Blvd." gives us a clue today as to the erosion rates of the coastline (see foldup map in rear pocket).

The construction of the Half Moon Bay Airport, commencing in 1943 , resulted in an alteration of the drainage pattern of the terrace, the surface runoff being collected in feeder ditches emptying into a large collector ditch which passed under the apron of the runway and thence into the marsh area. This ditch was excavated to a point about 400 ft. toward the marsh from Airport St. A right-of-way for the ditch still shows on the current maps all the way through the marsh to the road culvert, but it apparently has never been used. The airport construction had a notable impact on the vegetation of the area.

A power pole line extends along the entire eastern border of the marsh. In addition, the sanitary district has installed a small-diameter effluent line running underground (beneath the trail) along the western boundary of the marsh. This line blows out occasionally, creating minor pollution incidents. The beach bar area of the marsh is used in quasi-legal fashion by campers with self-contained vehicles,

The U. S. Air Force established its Pillar Pt. Missile Tracking Station around 1968 , and the access road to the point assumed its present form at that time. The road and culvert have had an important impact on the marsh.

Commencing in 1959, the U. S. Army Corps of Engineers undertook construction of the Pillar Pt. Breakwater to form Pillar Pt. Harbor. The project was completed in 1967, and has had a pronounced effect on the coastal erosion in the area and on the tidal influence on the marsh.

PHYSICAL ENVIRONMENTAL SETTING

This section covers both the general status of the marsh at this point in time and its specific physical condition prior to and immediately following the first rains of 1976-77. Thus, this part comprises the "base-line" data. Considerable reliance had to be placed on information already available on the marsh area, because of the limited amount of time and funds available for its study. Such information (properly referenced) is combined here with the original data gathered in order to give a coherent picture. The dynamics of the marsh ecosystems as related to moisture are also treated wherever evidence of the past physical history of the marsh exists. Principal sources for the abiotic and biotic factors of the marsh are Lowney-Kaldveer (1974), San Mateo County, Department of Parks and Recreation, Final EIR for Fitzgerald Marine Reserve (1976), J. H. Thomas's A Flora of the Santa Cruz Mountains (1961), and Roman Gankin (personal communication), who investigated the marsh in connection with the EIR for the Denniston Creek Project.

Geology

The coastline in the Half Moon Bay area is dominated, as is most of the California coastline, by the first ocean terrace (dated at 100,000-130,000 years). Folding of the earth's crust in this region has resulted in a warping of the terrace so that from an elevation of around 100 ft. north of Pescadero Cr. it descends to below sea level at Half Moon bay, rises again at Moss Beach, and drops again around Montara. Additional evidence of the warping of the terrace is the deflection of coastal streams as they arrive onto the terrace before reaching the ocean. Thus, Pescadero, Tunitas, Lobitos, Purisima, and Pilarcitos Creeks all are deflected northward, while Denniston Cr. is deflected southward, but San Vicente Cr. is deflected northward. The below sea level condition of the bedrock at Half Moon Bay appears to be intimately connected with the soils, the marsh, and the groundwater condition of the area.

The Pillar Pt. area has also been substantially altered by faulting.(Fig. 3). The Seal Cove Fault is a right-lateral, strike-slip fault with vertical components (Wesson et al, 1975), and is presently active, according to Brown (1972). While the geomorphology of the narrow Pillar Pt. ridge running from Seal Cove to Pillar Pt. suggests the existence of a secondary fault parallel to the Seal Cove Fault and running along the beachline (appearing in Fig. 3), La Joie (1977) doubts its existence, since no evidence has been found in the sea cliff. A third minor fault, lying parallel to Highway 1 and about 800 ft. upslope of it on the Denniston Cr. alluvial fan, has been partially mapped by the USGS (Lajoie, 1977). Lowney-Kaldveer (1974) also located this fault by magnetometer traverses, but did not ascertain the bedrock alignment by borings. The fault is upthrown on the east side, and bedrock may be displaced. Thus, the block of the terrace on which the marsh sits may be a graben (sunken block), while the Pillar Pt. ridge is either a horst (raised block) or an upwarped section of terrace vertically offset about 150 ft. along the Seal Cove Fault. The fault and offset have been fundamental to the formation of the marsh. The trace of the latter fault runs along the foot of the hillside on the western boundary of the upper marsh, and then passes, concealed under the marsh, directly beneath the culvert, and along the eastern edge of the saltwater marsh and underneath Pillar Pt. Harbor.

The bedrock composition and contours were investigated by Lowney-Kaldveer (1974). The bedrock is Purisima siltstone of lower Pliocene age, as is typically found on the first terrace along this part of the coast. The entire area is assumed to be underlain by the Montara granodiorite basement complex of rocks which are exposed in all of the highlands east of the airport terrace, and which furnish the large proportion sediments transported down onto the airport terrace. The bedrock block underlying this terrace lies approximately horizontal in the east-west direction, but dips to the southeastward toward Half Moon Bay. Bedrock generally lies at around -30 ft. elevation at the northwest end of the airport, and -50 ft. at the shoreline of the harbor. The marsh sits on the western edge of this block and its saltwater portion on a splinter block, possibly.

The Half Moon Bay area has been undergoing fairly rapid coastal erosion during Holocene times, apparently because Pillar Pt. cuts off any sand supply which the area might receive from northward up the coast, and because there are no major streams to augment this supply until further south along the coast. Tinsley (1972) and Lajoie and Tinsley (1974) have determined the erosion rates in the area for the period 1861-1973, and have found a recession of the beachline of about 250 ft. during this period, or a rate of 2.1 ft./yr. This rate should have been markedly reduced by the construction of the breakwater (1959-67).

An important geological question concerning the marsh is whether or not the landscape in the marsh area is uplifting at a substantial rate. The 1931 aerial photo shows the marsh inundated to the present 7 ft. contour or slightly higher. Since 1930-31 is one of the driest years on record, one wonders if the flooding of the marsh was not accomplished by the ocean. Since the maximum tidal elevation today is only 3.7 ft. (for 1976, and 5 ± 0.5 ft. max in recent years), it appears possible that the land in the area may have risen 2-3 ft. over the past 46 years. If so, this would have modified the tidal effect and the nature of the marsh considerably.

The airport terrace bedrock is overlain by a combination of stream wash and basin alluvial deposits. These surficial materials have been recently mapped by Lajoie, Helley, Nichols, and Burke of the USGS (1974), and range from 60 ft. thick on the eastern edge next to the spurs of Montara Mountain to less than 20 ft. thick at the Seal Cove Fault on the western edge. The latter structural feature effectively cuts off the aquifer layers. In the marsh proper the thickness of sediments reaches a maximum of 55 ft. on the eastern edge and averages around 35 ft. over the entire area. At the northwest corner by the sewage treatment plant, the thickness is over 40 ft., according to Lowney-Kaldveer (1974).

Lajoie and coworkers have mapped these surficial materials in the area of the marsh and airport as follows (Fig. 3):

<u>Younger Undeformed Deposits</u>

Qyfo <u>Fine-grained younger alluvial fan deposits</u> - unconsolidated, moderately-sorted fine sand, silt, and clayey silt. Deposited by streams primarily during floods.

Qb Younger basin deposits - unconsolidated, plastic, organic-rich silt and silty clay. Seasonally saturated. Deposited from standing flood waters which periodically inundate interfluvial basins.

Older Undeformed Deposits

Qof Coarse-grained older alluvial fan and stream terrace deposits - weakly consolidated, moderately weathered, irregularly interbedded gravel, sand, and silt. Coarse-grained at heads of old fans and in narrow canyons. Deposited by streams on old alluvial fans.

Slightly Deformed Deposits

Qmt Marine terrace deposits - weakly-consolidated, moderately weathered, well-sorted to poorly-sorted sand and gravel. Deposited in shallow water on old wave-cut marine terraces now warped and elevated above sea level. Locally upper parts deposited subaerially.

The majority of the marsh area, that part located in the lowest elevation, consists of the younger basin deposits (Qb) carried in by runoff from the airport area and by intermittent floods from Denniston Cr. These fine-grained sediments are the parent material from which the Denison clay loam soils are formed. Bordering these basin deposits are the fine-grained younger alluvial fan deposits (Qyfo) which cover the remainder of the marsh area and extend eastward beyond the toe of the airport runway. It is possible that these latter sediments were laid down by Denniston Cr. earlier when it had a different alignment. They have given rise to the Denison loam soils, even coarse sandy loam in some cases.

The majority of the airport terrace immediately above the marsh is covered with the coarse-grained older alluvial fan and stream terrace deposits (Qof), which, as already noted, become thicker toward the mountains to the east. These coarser sediments give rise to the Denison clay loam soils in better drainage situations.

Hydrology

The hydrology of the marsh and its immediate environs, and its relationship to the biota of the marsh are the principal concerns of this study. The hydrologic cycle, particularly of the underground system, determines the existence of the marsh, and any major changes in it will certainly be reflected as changes in the biotic makeup of the marsh. The hydrologic status of the marsh will depend upon the following factors: (1) the groundwater storage capacity of the upslope area supplying the marsh, (2) the percent stored at a given time, (3) the annual amount of recharge to the underground, (4) the transmission rate through the aquifers to the marsh, (5) the rate of subsurface outflow, and (6) the rate of evapotranspiration.

Using the estimates of Lowney-Kaldveer (1974), we can endeavour to obtain an idea of the operation of the hydrologic cycle in the airport terrace and marsh areas. The basin storage capacity is given as:

	Acre Feet
Denniston Creek subarea	1800
Airport subarea	4630
Total Storage Capacity	6430

The hydrologic inventory on an average yearly basis is given as:

	Acre Feet
INFLOW	
Streamflow	9600
Precipitation on Valley Floor	1050
Subsurface Inflow from San Vicente Subarea	350
Subsurface Inflow from Consolidated Rock on Margin of Basin	0
Total	11000
OUTFLOW	
Stream Flow to Half Moon Bay	7300
Evapotranspiration	1250
Subsurface Outflow to Bay	1200
Pumpage for Irrigation	500
Surface Water Exported from Basin by CCWD	400
Miscellaneous Pumpage (Domestic & Municipal)	350
Total	11000

By subtracting the surface outflow components (stream flow and surface water exported) from the total outflow, one arrives at an estimate of the average annual recharge to the underground, which amounts to 3,300 AF. Of this, 1250 AF would go to evapotranspiration, 1200 AF would be subsurface outflow to the bay, and the remaining 850 AF would be pumped for agricultural, domestic, and municipal uses.

If an additional 400 AF were pumped, raising the total pumped to 1250 AF, this increment would come out of the evaptranspiration and subsurface outflow components, presumably mostly out of the latter, and it is the latter which principally supplies the marsh with its water. The flow to the marsh (which is estimated here to be about 75% of the total subsurface flow, based on the groundwater contours given by Lowney-Kaldveer) could then be reduced from around 900 AF to around 600 AF at the worst, probably somewhat less. There will be some additional surface flow to the marsh which will remain unchanged, but which is not considered here.

A key question here is whether or not this decrease in underground flux would really affect the marsh. One must consider the storage picture of the terrace as well. The estimated capacity is considerable, 6,430 AF. Lowney-Kaldveer (1974) and Lajoie (1977) both consider that full capacity is achieved in the average year, based on 1974 data (a wet year) and on the fact that the farmers encounter wet soil conditions in the center of the terrace during a number of years. We prefer here to be a bit more conservative and consider that about 90% of capacity, i. e. around 5,800 AF, is the average storage, based on the fact that the San Mateo Area Soil Survey (USDA, 1961) shows essentially no seep areas on the terrace except immediately west of the San Vicente Resvr.

In any event, the increment to be pumped, and even the total pumped outflow, is relatively small compared to average storage. Even more important, however, is the shape of the underground storage and the water table contours. It was already developed in the section on geology that the terrace sediments increase in thickness to the east away from the marsh. Thus, the majority of storage lies further upslope. However, the water table contours modify this picture. In a wet year (1974) the contours are very close to the surface over the entire terrace, generally lying slightly above the surface (i. e., seepage would be generally occurring) on the lower slopes, and generally a foot or two below the surface on the upper slopes. However, in the dry period of December, 1975 until the present (CCWD, 1976) the water table contours have been as follows (see also Figs. 4 and 5):

(all values are elevation ASL in ft.)

Monitor Hole	Surface	Bedrock	Water Table 1/5/76	2/19/76	5/3/76	6/28/76	12/ /76
M1	41	-29	28	26	23	20	17
M2	55	-27	29	26	22	21	18
M3	66	-31	31	30	28	25	21
M4	35	-36	22	22	20	16	15
M5	24	-30	--	17	14	14	12

Inspection of this data will show that the water table gradient is considerably less than the topographic gradient. By December , 1976, the depth to water table in the highest hole (M3) is 41 ft. or 42% drawdown, while that at the lowest hole nearest the marsh (M5) is 12 ft. or 22% drawdown. Thus, transmission is sufficiently high that the marsh area probably always maintains the highest relative water tables.

The other interesting observation to be made from the foregoing data is the percentage of storage capacity filled after 1½ years of drought. A simple estimate based on the % drawdown indicates that the underground storage is still more than 50% full. From the hydrologic inventory presented earlier, we would suppose that two years of drought would largely empty the storage. Yet, it seems clear that in drought years, a larger proportion of the stream flow would recharge the underground. A typical drought year would have just about 50% of average precipitation, e. g., 13 in. as compared to an overall average of 27 in. (Teter, 1976) at Half Moon Bay. If this gives half the normal streamflow input to the area (and let precipitation on the valley floor balance out increased evapotranspiration), we would have about 4800 AF input as compared to 11000. In the average year 30% of the total imput goes to recharge. If this percentage rose to 50% in a drought year, some 2400 AF would be added, which would be 70% of the average recharge. In any event, there is bound to be appreciable recharge. Beyond this, also, the lower the water table gets, the smaller the underground losses to evapotranspiration and outflow become. In other words, the underground is the ideal area for storing water, unlike the surface, and is the hydrologic system's great buffer against droughts.

Regardless of the validity of the foregoing estimates, the marsh clearly sits in a favored location to receive the maximum flow of groundwater and enjoy the highest water tables. The configuration of the aquifers and the barrier of the fault scarp insure this . On the basis of hydrology alone, the marsh would appear to have adequate water supply in the average year, even with the 400 AF additional pumping. The case for drought years, however, needs to be tested in actuality as well as in theory. The recent two years arepermitting us to observe such effects on the marsh.

Soils

The soils of the marsh are one of the elements of the ecosystem which is most closely tied to the moisture regime, and merit monitoring in a number of respects (Fig. 5).

The marsh soils derive largely from the sediments laid down, as already discussed under geology, since, essentially, these are all alluvial soils. As such, they are poorly developed Entisols or else Inceptisols (where drainage is impeded), and their nature and profile is determined principally by their parent material (i. e., the alluvial deposition patterns) rather than by any soil forming processes (except gleization in the case of the Indeptisols).

The soils below the 7 ft. contour in the freshwater marsh area are the basin type soils with clay or clay loam surfaces. They exhibit great variation in texture with depth and almost no developed profile. The A Transect (Fig. 6, refer to soil plots and legend preceding), B Transect (Fig. 7), and D Transect (Fig. 9) all show the profiles, soil moisture, and water table for the basin type soils which are found in each case below the 7 ft. contour. These soils support the aquatic type vegetation and generally have the heaviest textures. Some parts of the profile are almost peaty in consistency, especially where cat-tails and tules dominate. The clays tend to be of a heavy consistency, probably due to previous saltwater intrusion and resultant flocculation.

Soil moisture determinations were completed before the rainy period of 12/31/76-1/2/77. The clay soils always hold higher percentages of moisture than the sandy soils, up to 222% (based on their dry weight) in the lowest part of the freshwater marsh. The water table prior to the rains lay well below 2 ft. in even the bottom of the marsh. After the first day of rain, standing water appeared up to the 5'-4" contour, and was visible in many of our 2 ft. deep soil coring holes. By 1/24/77 the standing water was higher at 5'-8", but the water table was dropping around the edges of the marsh, indicative of the lag due to transit time through the aquifer. There were slightly perched water tables on some of the more clayey areas .

The salinity of the soils in the B and D Transects was measured, the results being given in millimhos of electrical conductivity. The basin soils show the highest levels in the freshwater section of the marsh, up to 2.0 mmhos, but these levels still correspond to only 200-300 ppm dissolved solids which is equivalent to relatively hard drinking water. The equivalent amount of NaCl is 3-4 milliequivalents per liter in the saturation extract, or 250 ppm based on the soil weight. This degree of salinity is typical of the Denison soils.

Between the 7 and 8 ft. contours lies the intermittent flooding zone. In this zone the soils frequently show intense mottling throughout some or all of the profile. This condition develops chiefly in the heavier textured soils where air cannot move in and out of the wet soil as easily. The mottling is the result of differential oxidation brought about by a fluctuating water table. Transect B affords an excellent example of this. The same zone supports the amphibious type of plants such as the knotweed. These soils generally have a loam to sandy loam or even sandy surface texture. They may have heavier textured layers underneath, but these do not represent translocated clay. The soils are still Entisols, but drainage is sufficiently improved here that soil profile development must be going on.

The soil moisture in these soils during the dry period was around 50%, and the conductivity ran 0.5-1.0 mmhos or 60-120 ppm NaCl by weight. The water table is able to fluctuate in these soils more readily due to somewhat improved internal and external drainage. The former, due to some coarser-textured layers in the soil, permits faster vertical movement of water in the soil, while the latter results from the increasing slope. Since this zone lies immediately above the saturated zone, the external drainage conditions fluctuate considerably.

Somewhat on the periphery of the marsh occur the fan-type soils formed on coarse-grained sediments (Transect D, Fig. 9). These generally occur between the 7 and 9 ft. contours. The soils are a sandy loam or loamy sand in texture, often throughout the entire profile. The drainage is excellent, there are no signs of mottling, and there are relatively few soil arthropods. The soil moisture in these coarse-textured soils is always low, running around 25%. The blackberry forms extensive monocultures on these areas, but the sedge also becomes established on some locations.

Above the 9 ft. contour lies the terrace sediment soils which generally enjoy moderate to well drained conditions. Our sampling program has not yet covered these soils. It is clear, however, that the basin soils are quite young examples of the Denison soils, and that the soils progress in age and development as the elevation increases. Thus, one expects to find more like the true Denison soil on the terrace with a rather well developed B horizon. These soils appear to depend upon a certain salt content initially for their formation. As the soil is raised up into a better drainage situation, the salt is gradually leached into the subsoil, dispersing the clays and moving them downward as well. In the subsoil the residual salt concentration brings about flocculation of the clays.

The coarse-textured soils associated with blackberry are closest to an imperfectly formed Farallone soil. This latter soil is formed in granitic alluvium, usually with a sandy loam or coarse sandy loam texture. It is a highly fertile soil. Our soils do not have sufficient clay to usually be considered loams. Hence, the soil is a Farallone sandy soil which awaits the deposition of sufficient clay so that a loamy texture can develop.

The soils along the north lobe of the marsh, generally following the alignment of the A Transect, are distinctly more spotty in their distribution. They lie somewhere in between the basin and alluvial-fan soils, since at times a stream develops through this part of the marsh. Thus, some of the soils are clayey in the surface, while others are sandy. Furthermore, this distinction is not determined by elevation alone. The raised areas on which the willows like to locate have many clay soils on them. This fact suggests that heaving and sagging of the surface occurs frequently in the fault zone, since the clay soils had to be layed down in the depressions originally.

The soil profiles examined (see transects) show a considerable amount of migration of plant boundaries with time. The reddish, woody rootstocks of <u>Polygonum coccineum</u> or Swamp Knotweed are found over much of the marsh. This is to be expected, as it occupies the intermittent flooding zone. While it is a versatile plant, its wide distribution suggests that the water levels of the marsh have fluctuated considerably with time. More interpretation is required on this kind of evidence.

A number of soil arthropods and invertebrates have been discovered and collected. The identification of these is a rather formidable task, requiring a number of different specialists. Some of the more common species are presently being identified, and we are trying to establish a satisfactory method for quantitative separation of them from the soil. A stout-bodied annelid (earthworm) is one of the most common, and can usually be found a few inches above the water table in the more fertile soils of the marsh.

It has not been possible to sample soils in the saltwater marsh yet, and it was given a low priority. The marsh waters have been tested for salinity. Sampling was done on 12/31/76, after one day of rain and 12 days after the highest tide of the year. The tides may have more to do with the salinity of the lower marsh than the precipitation will have during a drought year. The results were as follows:

Location	Conductivity (mmhos)	NaCl Equiv. (ppt)
culvert end of lagoon	142	7.8
east side of lagoon	341	18.9
outlet of slough	348	19.3

The salinity of the lower marsh waters are, thus, at least 100 fold those of the upper marsh. The culvert area is brackish, as is also evidenced by the vegetation. The southern outlet end of the lagoon is about half the strength of seawater (35 ppt). The culvert and road thus effectively keeps out seawater from the upper marsh.

Vegetation

The vegetation is also one of the fundamental indicators of the moisture regime both in regard to migration and physiolological behaviour. In the marsh it divides quite clearly into freshwater and saltwater sections. A narrow band along the southern boundary of the access road in the center of the horseshoe can be considered transitional or characteristic of brackish conditions. As in most marshes where a pronounced moisture gradient exists, the vegetation appears essentially in zones determined by elevation. These zones correspond rather closely to either the soil or salinity zonation or both. It is, therefore, convenient to consider the marsh vegetation here in this manner.

The species list of flowering plants and cryptogams is given in Table I. Fig. 11 gives a vegetation map for the entire marsh, and Fig. 12 a detailed map of the critical area on both sides of the road. The distribution of vegetation along the moisture, salinity, and soil gradients is given with each transect.

Aquatic Zone

The species of the freshwater marsh area in the lowest zone characterize it generally as an intermittent rather than a permanent marshland. There are only a limited number of truly aquatic plants present. In this category there are several emergent species, but essentially no floating or submergent species (at least none evident during this drought period). The zone has been designated as aquatic, and is characterized by the following species:

Typha latifolia	Broad-leaved cattail
Typha angustifolia	Nail Rod
Typha glauca	
Sparganium eurycarpum	Bur Reed
Scirpus californicus	California Bullrush
Scirpus microcarpus	
Juncus effusus var. brunneus	Rush
Equisetum Telmateia	Giant Horsetail
Cicuta Douglasii (limited extent)	Water Hemlock
Oenanthe sarmentosa	
Epilobium Watsoni var. franciscanum	Willow Herb

Typical emergent genera which are conspicuous by their absence are Marsilea (Water Fern), Potamogeton, Alisma (Water Plantain), Sagittaria (Arrowhead), Lemna (Duckweed), Ranunculus, Rorippa, Berula, and Bidens. The zone extends from the upper side of the road, starting at the 5 ft. contour to the 7 ft. contour, and can be characterized as that part of the marsh in which water stands most or all of the wet season during the average year.

The transect data indicates further differentiation by elevation which probably corresponds to different tolerances for salt and/or immersion. Thus, Typha angustifolia is found at the lowest level, while T. latifolia extends from there to higher elevations. Scirpus californicus is found in the low areas, but S. microcarpus is only found at the upper fringes or in the next zone above. In the case of Typha, salinity is the controlling factor, as T. angustifolia is clearly found in the brackish zone, while T. latifolia is found only sparingly. In the case of Scirpus it is not clear, but both salinity and immersion may be important. Sparganium is an example of a species found throughout the zone and beyond, and must have a wide tolerance for salt and moisture. Another species of extremely wide range, which dominates the zone above, is Polygonum coccineum which is found at lower densities at the lowest elevations. The willow, Salix lasiolepis, which is also present in the aquatic zone, is treated separately because of its unique distribution.

Intermittent Flooding Zone

Immediately above the preceding zone (approx. 7 to 9 ft. contours) lies the Intermittent Flooding Zone. Here the water stands for only relatively short periods of time, possibly as long as a month, and the zone dries out quite thoroughly during part of the year. Whereas the aquatic zone corresponds to the basin soils, this zone corresponds to the mottled transitional soils. The zone is dominated by the Swamp Knotweed, Polygonum coccineum, which tends to develop 100% cover over large areas of the zone. In many areas, the former species has an undercover of Pacific Silverweed, Potentilla Egedii var. grandis. The latter species seems to manage to exist at a considerably reduced light level beneath the dominant. The knotweed is an amphibious plant which is uniquely adapted to both terrestrial and emergent conditions, or more properly, floating conditions. The leaves and stems are adapted to floating when water is present, but, in its absence, the stems have sufficient strength to support the leaves for terrestrial operation.

The transects all give evidence of the wide range for Polygonum coccineum, which extends well into the zones above and below its own. It appears to find its optimum in the zone of fluctuating moisture and relatively low salt content. It should also be noted that Scirpus californicus is often found in the area where P. Coccineum is at its maximum density. S. microcarpus is also typical of this zone, appearing both as a co-dominant with P. Coccineum and in almost pure stands on its own. This species appears to not tolerate salt, since it grows well in the airport drainage ditch where standing water is common and again in the very northern end of the marsh (Transect A, L, and M). It tends to be located at the upper edge of the present zone or even higher.

We will include in this zone the area at the very northern end of the marsh, designated on Transects L and M (Fig. 6). There is insufficient evidence yet as to the exact type of moisture regime found in this area. It is obviously a moist area, but whether or not it is subject to intermittent flooding, we cannot be sure. The principal species are Water Hemlock, Cicuta Douglasii, Bur Reed, Sparganium eurycarpum, and the above species, Scirpus microcarpus. These same species are found in Transect B at the upper end of the intermittent zone. It is possible that they are located this high up because of salinity conditions. They may also prefer flowing to standing water conditions. The Water Hemlock arises from a fleshy rootstock which is readily detached and transported, probably by moving water. The species has managed to distribute itself to some degree around much of the marsh area. It also responds quickly to improved moisture conditions, sending out new shoots upon the first sporadic rains at the end of the dry period.

Well-Drained Marsh Zone

The third zone, which extends from the 7 to the 10 ft. contour, is determined as much by soil texture as by moisture. It occurs on the imperfectly formed Farallone soils, and is designated as the Well-Drained Marsh Zone, since it retains a fairly high moisture level. The lower end of this zone is dominated almost totally by California Blackberry, Rubus ursinus. This species produces almost impenetrable thickets under these conditions, outcompeting all other species. It is undoubtedly important food for wildlife, and the brush rabbits were found eating the dried canes this drought year to the point where one would think they were ingesting nothing but pure cellulose. The *Polygonum* and *Rubus* upper plant parts were so dry by December of 1976 that they would have easily burned up with the assistance of a careless match. The thickets are also excellent cover for ground-nesting birds and mammals such as the brush rabbit.

The blackberry forms almost a continuous band around the edge of the marsh on the east side where the elevation gradient is gradual. On the upper edge of the zone it gives ground to the sedge, *Carex obnupta*, and to some of the terrestrial species which are invaders. In the north-central marsh *Rubus* forms a mosaic of communities with *Carex*, *Aster*, and *Juncus*.

Transition Terrestrial Zone

The zone which joins the marsh area to the surrounding terrestrial areas extends from the 9ft. to the 15 ft. contour roughly, and is termed Transition Terrestrial here. This zone is a major ecotone, since it consists largely of plants from the two foregoing major areas which tend to invade each other's territories.

The first group of species found here are the drier marsh plants which tend to invade the terrestrial area to some degree. These include *Carex obnupta* and the Bog Rush, *Juncus effusus* var. *brunneus*. The *Carex* grows in this zone and the upper edge of the previous zone in dense tufts or mats. It is a major component in a band running along the entire east and northeast border of the area as far as the most northerly large copse of willows. The *Juncus* is more selective in its location, which is largely around the outlet of the airport drainage ditch, although it also is found intermingled with *Carex* in the northcentral marsh, but usually lies uphill of it. Thus, this species shows some adaptation to intermittent flooding, but probably on the drier end of the moisture gradient.

The second groups of species are the terrestrial plants adapted to invading the marsh. A number of these are weedy plants with generally aggressive, invading potentials. They are almost certainly present due to the disturbance created by the construction of the Half Moon Bay Airport, at which time they got a foothold in the area. Two of the four species listed here are invaders from other continents, and none of them are normal components of the natural grassland and scrub communities of the coast. The principal species are Bull Thistle, *Cirsium vulgare*, Poison Hemlock, *Conium maculatum*, Fireweed, *Erectithes prenanthoides*, and Common California Aster, *Aster chilensis*. Any further drying up of the marsh from its present state will favor the invasion of the area by these weedy species, and such an invasion would be a major loss, ecologically speaking, as the above plants do not have the value of the native plants in terms of food and habitat for wildlife. Furthermore, they are really not as well adapted to the environment as are the natives and are only a passing phenomenon. Also, at least two of these weeds are noxious to man.

Terrestrial Zone

The Terrestrial Zone, so-called here, is really the general area surrounding the marsh above the 15 ft. contour. All of this zone on the east and northeast borders of the marsh is a disturbed field adjacent to the airport to the east. The native vegetation of this zone was probably alternating coastal grassland and northern coastal scrub. This was long ago modified by agriculture and later by the airport. Most of the original perennial grasses have been replaced by annual grasses, and, what is even worse, by weedy herbs. The weedy species considered in the previous zone are largely predominant in this zone also. Even the remnants of the northern coastal scrub community, dominated by *Baccharis pilularis* ssp. *consanguinea*, are being broken up by the weedy invaders.

The zone continues on the west side of the marsh on the slope of the Seal Cove Fault Scarp. Here lies a large expanse of the northern coastal scrub community, interspersed with a few small grassy areas. This part of the zone is notable for almost a complete absence of the weedy invaders of the east side.

Our monitoring efforts generally have stopped short of this zone.

Willow Copses

The two species of willow found in the marsh dominate a considerable fraction of the area of the freshwater marsh and a limited portion of the saltwater marsh. The more prevalent of the two species is *Salix lasiolepis*, the Arroyo Willow, which forms large thickets, some isolated, and others connected into extensive areas. This species is found throughout the two lowest zones already considered, and one small copse in the upper end of the saltmarsh section. It is assumed from this distribution that this species tolerates low levels of salt. The other species, *Salix Coulteri*, the Coulter Willow, however, is restricted to near the north end of the marsh and to the airport drainage ditch, in both cases lying above the 10 ft. contour. It appears, therefore, that the latter species is restricted to freshwater habitats.

The willows are found growing both on top of the narrow, low ridges thrown up in the fault zone, and in the lowest, wettest areas of the upper marsh. This is particularly true of *Salix lasiolepis*, and in January the low lying willows are all found in standing water. It appears that they are not particularly soil sensitive. The 1931 aerial photo of the marsh shows a much less dense growth of willows which seem to be restricted to the ridges, by the spatial pattern observed. This is interpreted, once again, to mean that the willows tolerate only a low salt concentration. It appears that in the earlier years the ocean tidal influence extended farther into the marsh. The one defense the willows had against such salt invasion was to locate on the higher ground in the middle of the marsh. Today, with less salinity, the willows are apparently slowly invading the marsh. They have the important advantage of having a deep root system, which gives them a steady water supply in the marsh area even in dry years. In the marsh they grow to be trees 25 ft. or more in height, and must have extensive root systems. One possible change in the marsh that would occur if moisture levels drop at the surface is the invasion of the willows over much of the rest of the marsh, making use of the deep moisture supply.

The willows dominate their areas almost exclusively, producing impenetrable thickets in places. Where the trees are more mature and the understory more open, Athyrium felix-femina, the Lady Fern, and Polystichum munitum, the Sword Fern, are found in small clumps. Toward the northern end of the marsh where intermittent flooding of the willows occurs, and where the ground remains moist even in drought periods, the entire floor of the willow copses is covered with the creeping, climbing Senecio mikanioides, German Ivy.

Nettle Invasion Areas

The Coast Nettle, Urtica californica, one of the stinging nettles, is singled out for comment here because of its extreme aggressive invasion potential. It is found throughout much of the lowest two zones of the freshwater marsh. It is a noxious weed to both the ecosystems of the marsh and to man. During this drought period this species has moved into the lowest zone and is killing off and displacing Scirpus californicus at many points (see vegetation maps). We need to gather more data on this plant's distribution, as it is probably one of the better moisture indicators. There has been a tendency to avoid the nettle areas because of the plant's noxious properties. The species is adapted to the moisture regime of the intermittent flooding zone, and once the aquatic zone dries to a similar level, the nettle becomes very aggressive there.

Saltmarsh Zone

The saltmarsh zone comprises that area south of the road and generally below the 5 ft. contour. The large majority of this area, except for the open water in the center, is under 100% cover of Salicornia virginica, Pickleweed. In most of the salt marshes of our coast pickleweed occupies a well-defined band in the upper tidal zone. The species requires a minimum of 0.41% salt and can stand submersion in water up to 3.3% salt concentration (i. e., about 90% of seawater salinity). Some pickleweed species can tolerate up to 4.25% salt in the soil water (Chapman, 1975). At the same time, however, the species apparently requires lower salt concentrations seasonally for seed germination, which depends upon the winter rains (Conradson, 1966).

The dominance of pickleweed in the zone indicates that seawater incursions are only occasional on the higher tides, and that, with the flow of fresh water through the marsh during the winter, the zone is brackish during the winter, and probably reasonably saline during the summer. The salinity data obtained so far, presented in the discussion on soils, appears to substantiate this concept, although this dry year is not typical. The average conditions of the zone favor pickleweed.

On the northeastern corner of the zone Juncus Lesueurii, the Salt Rush, grows in a luxuriant swatch. The area borders on the brackish zone. At the other end of the zone at the slough mouth, the salt-adapted grass Distichlis spicata, Salt Grass, is found.

Transects E and F (Fig. 10) show the horizontal distribution of the saltmarsh species. More work needs to be done in this part of the marsh, but it was felt that the emphasis should be put on the fresh-water section to most quickly solve the problem at hand. Transect E shows the zonation according to salinity. The center of the transect (around the 150 ft. mark) is the point of maximum salinity, while the edges represent lower salinity conditions. On the edge of the pickle-weed area one finds Jaumea carnosa. The two Typha species are in the brackish zone (the central patch being a point of higher ground extending into the pickleweed zone). Transect F centers upon the Jaumea sub-zone, with Frankenia grandifolia also present. The ends of this transect fall in the brackish zone, with Typha glauca and Juncus Lesueurii. At the high salt concentrations found in this area, salinity gradients determine the vegetational gradients.

Brackish Zone

The Brackish Zone lies in the northern end of the southern section of the marsh next to the horseshoe section of the road and the culvert, its only source of fresh water. It included the following species: Typha latifolia, T. angustifolia, T. glauca, Juncus Lesueurii, Polygonum punctatum, Scirpus californicus, Urtica holosericea, Frankenia grandifolia.

Terrestrial Zone

In general, fault scarps on both sides of the lower marsh produce a sudden change from brackish to terrestrial. Here the terrestrial zone is somewhat different from the earlier zone surrounding the freshwater marsh. In addition to the Baccharis scrubland and the weedy fields, there is a border on the west of plants which tolerate salt spray, such as Conium maculatum, Brassica campestris (Field Mustard), Artemisia Douglasiana (Coast Sagebrush), and Cupressus macrocarpa (Monterey Cypress). Rubus ursinus is also well represented on the eastside slope, and Salix lasiolepis is present on the road fill, as already noted.

The access road fill constitutes a disturbed zone which intrudes into the marsh and bears many weedy plants, including a few from the previous zone. These weeds do not colonize the immediate area, because any of the nearby areas are too wet for any colonization to be successful.

Other Zones and Species

Immediately next to the bay along the beach bar lies the usual coastal strand zone, with species such as Cakile maritima and Lupinus Chamissonis. This community, however, is of no concern in evaluating the marsh. Several species of plants are found sporadically around the area, somewhat irresepctive of zonation. Thus, Lonicera involucrata (Twinberry), Sambucus callicarpa (Red Elderberry), Cornus stolonifera (Creek Dogwood), and Myrica californica (California Wax-myrtle, are all found on the edge of the marsh in moist soils and usually in or near the willow copses. In addition, Rhamnus californica (California Coffeeberry), a species associating with both the Northern Coastal Scrub and the Chaparral communities, is found on the higher ground around the marsh.

ANIMALS

As in the case of vegetation, so also with the animals it is not our purpose here to make a thorough study of the species present or their populations. The concern is with those particular species which presumably will show the greatest dependence upon moisture conditions, and with the endangered and rare species known or believed to be present. A rather complete species list (SMCo, 1976) is given for the freshwater and saltwater marsh areas. Some 178 species are listed for the two areas, of which 154 were sighted, 5 were observed by indirect evidence, and 19 were assumed to have a high probability of being present, all data being obtained in the fall of 1975. During the months of November and December of 1976, an extremely dry period, we were able to observe only 50 species of vertebrates (Table II). The effects of the drought upon the animals are as obvious as on the plants. As already noted, however, the separation of the effect of pumping a limited amount of groundwater from that of the normal fluctuations of the hydrologic cycle, in terms of higher animal behaviour, would be difficult indeed.

In the case of the vertebrates, we have attempted to obtain estimates of the abundance class for the more obvious species, based on sightings relative to various trap locations. In rare instances, such data may give clear clues as to the effect of even minor variations in moisture. However, as an example of the difficulty involved in this procedure, we may consider one example at the site. On November 16 there were 9 White-tailed Kites resident in the marsh, roosting in the willows and foraging over the adjacent fields. However, by December 1 only one kite remained. The species is a winter visitant to this area (present roughly September through April). The question is, why did the kites suddenly migrate away from the marsh. We assume that our presence was not the cause, since numerous children and other persons frequent the marsh. All of the ten kite scats examined contained the skeletal remains of Microtus californicus, which was apparently the birds' main food source at this late season. Similarly, it was found in 1975 that the owl population was relying principally on M. californicus. Microtus was heavily preferred over the more abundant Peromyscus, even though the latter was more abundant and was expected to be the normal prey of the nocturnal raptors, rather than the diurnal Microtus.

There can be little doubt that the Microtus population was low this fall because of the drought. While approx. 425 trapping days and nights gave 16 recoveries in 1975, 108 trap nights gave only one recovery in 1976. The location of the latter may also be significant, since it was a heavy stand of willows in which the woodland floor was all covered with German Ivy - the moistest area in the freshwater marsh at that time, and the only green area. This habitat, however, was not the normal open grassland type characteristic of Microtus. Since the species normally relies on fresh green plant material for its forage, it would be especially hard hit this season. There was also an absence of the usual runways and shallow tunnels of the species in the grasslands.

From the foregoing results one would tend to conclude that the kites migrated because of the decrease in Microtus population, the latter having been brought about by the drought. However, there is no direct proof that this is so. Furthermore, to prove that the prey population is being affected by well pumping would take a great deal of data over a long period of time.

Mammals

The case of the California Vole (Microtus californicus) has already been covered. In Table II a comparison is given for the two study years of abundance classes for the species throughout the various habitats. In general, the effect of the drought between the two years on abundances is striking.

The Brush Rabbit (Sylvilagus Bachmani) affords another example of mammals moving to areas of more moisture or else shifting food sources to survive the drought. The species has been commonly encountered in the well-drained marsh zone and the transition terrestrial zone, amongst blackberry, Carex, and rushes. The animals have been discovered both by flushing and by observation of scats. They have been reduced to eating green Carex stems, hardly a palatable food source, and the tips of blackberry shoots, much of which has become exceedingly dry and tough. The drop boards have given more quantitative information as to the location of the animals as follows:

Board Number	Total No. of Pellets	No. of Times Sampled
V1	3	7
V4	1	7
V5	10	7
V7	23	7
V9	9	7
V5a	3	7
P4	1	4
P5	4	4
C1	1	6

Both V7 and V9 are at the north edge of the marsh which has a dense vegetation of sedges, rushes, and blackberry next to the only area with green succulent vegetation. Area V5 has similar cover vegetation, but lacks the abundance of green material. Thus, the rabbit population tends to be concentrated next to the only source of green forage. The rabbit is an adaptable feeder, and its abundance does not appear to have changed that much between the two study years. This year we have observed rabbits being taken on several occasions by raptors, probably more heavily than in most years, due to the dearth of small mammals, the usual prey.

The Dusky-footed Woodrat (Neotoma fuscipes) was found to be a common resident underneath the willows. Approximately 20 houses were located on the site, all of which were built underneath or bordering the stands of willows, and were constructed chiefly of willow branches. The woodrat feeds largely on green vegetation when available, but is capable of adapting to whatever the environment has to offer, including herbage, grain, nuts, and fruits from a wide variety of plants (Vestal, 1937). It is believed that in this case the species was feeding on Arroyo Willows and Baccharis, amongst others.

According to the literature (Vestal, 1937) the densities of the woodrat may reach as high as 20.7 rats per acre in ideal woodland habitat, with over 90% of the houses (woodrats live singly, one to a house) being inhabited at one time. At the site, a 1.25 acre plot of willow habitat supported 14 rat houses with approximately 44% occupancy (as determined by observing the freshness of building materials used and whether or not disruptions to the structure were repaired). The low percentage occupancy this year is assumed to be due to both a lack of available food and increased predation on rats in the absence of the smaller mammals. Nevertheless, the rats appear to be faring better than many other animals, probably because the willows, amongst all of the marsh plants, are suffering the least. This condition results from the willow's ability to obtain water from the deep strata of the marsh which remain moist during any dry year.

The group of mammals which we expect to be most sensitive to moisture are the insectivores, i. e., shrews, moles, and bats. The can trap lines were set up largely for catching shrews, since our experience has been that shrews seldom enter the Sherman traps. No recoveries were made, however, this fall. In 1975, one Ornate Shrew (Sorex ornatus) was caught in a Sherman trap out of 85 animals taken. It would appear that the shrew population was already low in 1975, due to the start of the drought, and it may well be decimated locally by now. It is difficult to see how a genus which cannot hibernate, must eat constantly, and requires moist conditions could survive presently. It may be difficult to use the shrew population as a means to studying the effects of moisture, because of the uncertainties involved in reestablishing the local population. The Broad-footed Mole (Scapanus latimanus) was observed as a common marshland resident in 1975, and a few mole diggings were noted this November in the transition terrestrial zone before the drought became intense, but there has been no evidence of moles since then. Of the twelve species of bats which could inhabit the marsh, only indirect evidence for the California Myotis (Myotis californicus) was found in 1975. No bats whatsoever, have been evident this year, although we have not attempted to study them.

The Deer Mouse (Peromyscus maniculatus) showed low populations this fall. In 108 trap nights only 5 animals were taken, all of them the foregoing species. All five were taken close to standing water, four of them on the border of the saltmarsh, interestingly enough. These results compare with 18 of the species taken out of a total of 24 catches in the marsh in 1975, and 66 out of 85, respectively, in the entire area, based on approx. 425 trap day and nights. The Western Harvest Mouse (Reithrodontomys megalotis) was observed this year after the first rains. Two mice were captured in can traps B3 and B5, both in the Polygonum and Scirpus freshwater marsh areas. The species was never trapped in 1975. The mouse is primarily a seed eater (Ingles, 1947) and is typically found in moist environments (Berry, 1959).

None of the larger mammals, such as the raccoon, skunks, long-tailed weasel, fox, coyote, bobcat, or deer, save the first mentioned, have been sighted this year, although a number of these species were boserved in 1975.

Birds

Only the most abundant species of birds in which some population changes might be observable will be discussed in this section.

In the Salicornia saltmarsh the Long-billed Marsh Wren (Telmatodytes palustris) was most commonly seen feeding during the day, while retreating to the Typha-Scirpus freshwater marsh at night for roosting. The Western Meadowlark (Sturnella neglecta) has been observed resting in this area at sundown, as many as 41 birds at one time. This species is now showing some population decline generally. However, both of the foregoing species may be more abundant in 1976 than in the previous year. Various migratory waterfowl move through this part of the marsh in fall. Typical are the

Northern Phalarope, Shoveler, Pintail, Bufflehead, Common Goldeneye, and Willet. While three of these species were common last year, only the phalarope is in 1976 (it was rare last year). According to Merle Payne (1977), a graduate of Oregon State University in wildlife biology who has been visiting the marsh for years, there were far fewer birds using the standing water and saltmarsh area this year than in previous years.

The most common birds of the aquatic zone of the freshwater marsh are the Common Yellowthroat, Long-billed Marsh Wren, White-crowned Sparrow, and Song Sparrow. The first two species nest in the zone. The sparrows are often found along the marsh border, feeding on marsh vegetation by day, and roosting in the willows by night. One evening, 20 Song Sparrows were observed roosting in the ecotone on the north edge of the Salicornia, as do also the Brewer and Red-winged Blackbirds. The latter species probably feed in nearby fields by day, but roost in the marsh by night and use it for nesting grounds. At least in the qualitative sense, all of these aquatic zone species mentioned seem to show no population decline this year from last. The regular raptor of both the fresh and salt marsh zones is the Marsh Hawk, of which at least one female was much in evidence.

The willows afford an extraordinary food source for the birds, especially in the spring and summer, with a thick carpet of leaf litter which harbors a wide variety of invertebrates and frogs, salamanders, mice, and snakes. The aerial parts of the trees also afford excellent habitat for insects. The willows are somewhat unique in the are, however, in being fully deciduous, with the result that both food and cover above the ground level decreases sharply in the winter months. The habitat is an essential part of the migratory warblers' lives in the spring and fall. Only one warbler, the yellowthroat, has been observed this year out of the 26 species found in 1975, of which 5 were of common abundance. The Anna's Hummingbird, one of the few species to breed here in the winter, is presently setting up territories and conducting courtship flights. Both the Ruby-crowned and Golden-crowned Kinglets are prevalent, and Fox Sparrows are abundant, scratching in the leaf litter for small insects and seeds. In December, a Great Horned Owl was found roosting in the northern willows in midday; the roosting habits of the White-tailed Kite have already been mentioned.

The terrestrial zone (grassland and scrubland) and its transition to the marsh are the feeding areas of the majority of the large raptors, notably the Red-tailed Hawk, Sparrow Hawk, and White-tailed Kite. The first species was observed taking brush rabbits in the area on two occasions, as well as smaller mammals. All of these raptors appear to be opportunistic in their feeding habits, particularly in times of food scarcity. The Loggerhead Shrike is a common resident of the scrubland, as are also the Anna's Hummingbird, House Finch, and Bushtits in feeding.

The finch and meadowlark are the two species seeking seeds in the grasslands.

Reptiles and Amphibians

Reptiles and amphibians were both completely non-evident by the fall of 1976, except for the calls of a few tree frogs. Undoubtedly the populations had generally declined sharply due to the drought, and the cold temperatures had driven the few survivors into dormancy. The first real rains of December 31 brought out some of the amphibians. Three captures of the Yellow-eyed Salamander (Ensatina escholtzi xanthoptica) were made on that date, two in dense willow leaf litter. Three other captures had been made before the rains in the rushes and dense vegetation along the sewage treatment plant road, two of the salamander, and one of the California Slender Salamander (Batrachoseps attenuatus). According to Stebbins (1954) these two species are frequently found together because they seek the same habitat, namely, moderately damp surroundings without saturated soil. The first rains always bring them up out of the ground. Both species were found to be uncommon marsh residents in 1975. The can traps are effective in taking these animals.

The Tree Frog (Hyla regilla) is the most common amphibian in the area. It is most commonly found in the willow thickets, particularly in the green willow woodland. In that area on December 3 at dusk, the tree frogs entered into a typical active chorus and mating time, at which point it was possible, by careful listening, to estimate 13 frogs being in the area of about one acre. The frog may be a fairly good moisture indicator. While some varieties of the species may not tolerate salinity (Stebbins, 1954), the local frogs at Coyote Point apparently tolerate bay water (Kemnitz, 1977), so the species may not serve as a salinity indicator.

Only one reptile was observed by us on the site in 1976, the Coast Garter Snake (Thamnophis elegans terrestris). The snake was commonly seen sunning itself in the scrubland bordering the western edge of the marsh. It was seen at only two other locations, on the southern edge of the green willow area near the north boundary, and in the clearing, taken over by Water Hemlock, immediately south of the latter. These latter two areas were the moistest part of the marsh in the fall. After the cold spell of December the snakes were no longer seen and presumably had gone into hibernation.

A second reptile, the Western Pond Turtle (Clemmys marmorata) is reported to have been sighted earlier in the year by employees of the Granada Sanitary District. The turtles were seen near the standing water in the saltmarsh and were not uncommon during their active season (March-November). The species was not even listed during 1975. In general, it can be said that the populations of the above reptiles and amphibians appear not to be very different between the two years.

Endangered and Rare Species

The following animal species known or believed to be in the marsh area are recognized as either endangered, rare, or apparently suffering a population decline (National Audubon Society's Blue List):

		Presence in the Marsh
Endangered*:		
San Francisco Garter Snake	*Thamnophis sirtalis tetrataenia*	1975 possible WV
Peregrine Falcon	*Falco peregrinus anatum*	1975 rWV
Rare*:		
California Black Rail	*Laterallus jamaicensis coturniculus*	1975 possible rWV
Status Undetermined:		
California Red-legged Frog	*Rana aurora draytoni*	1975 possible WV
Sharp-tailed Snake	*Contia tenuis*	1975 possible rR
Blue List (Birds)		
Black-crowned Night Heron	*Nycticorax nycticorax*	1975 uR
Canvasback	*Aythya valisneria*	1975 rWV
Sharp-shinned Hawk	*Accipiter striatus*	1975 uWV
Cooper's Hawk	*Accipiter Cooperii*	1975 uWV
Red-shouldered Hawk	*Buteo lineatus*	1975 uMSF, uWV
Marsh Hawk	*Circus cyaneus*	1975 cWV 1976 cWV
Osprey	*Pandion haliaetus*	1975 rMSF
American Kestrel (Sparrow Hawk)	*Falco sparverius*	1975 cR 1976 cR
Barn Owl	*Tyto alba*	1975 uR
Purple Martin	*Progne subis*	1975 MSF, uSuV
Bewick's Wren	*Thryomanes Bewickii*	1975 uR 1976 uR
Loggerhead Shrike	*Lanius ludovicianus*	1975 uRMSF, WV 1976 cWV
Yellow Warbler	*Dendroica petechia*	1975 cMSF, SuV
Lesser Goldfinch	*Spinus psaltria*	1975 uR 1976 uR

The species of most concern in the area is the endangered San Francisco Garter Snake. The reports on the presence of the snake at the marsh

* - (CDF&G, 1974)

have been conflicting. While it was reported (SMCo, 1976) that Dr. Sean Barry, an expert on the species, had positively identified the species as being present in the marsh in 1972, it is our understanding that Dr. Barry himself has since denied that he found it at the marsh location (Kemnitz, 1977). At that time he did find five individuals of the species at the Denniston Creek Reservoir. Dr. Barry did state that he felt it possible for the snake to migrate from the creek to the marsh as a winter visitant, but that it would not reproduce in the marsh. Considering the strong migratory habits of the species (Lampman & Assoc., 1974), it appears possible to us for the snake to migrate to the marsh from the creek in any wet year when there are seepage conditions on the terrace, and by following the airport drainage ditch for the most part. So far this year we have seen no evidence of the species.

The other endangered species, the Peregrine Falcon, was sighted at the marsh in 1975, but has not been seen so far this year. It is now extremely rare in California.

The rare California Black Rail has been detected in other salt and freshwater marshes along the coast of San Mateo County. Being both secretive and small, it is difficult to detect. Of the three species of rails known to inhabit this coastline, it is the only one remaining undetected, so there is a distinct possibility that it is a winter visitant to the marsh.

The "status undetermined" class includes the California Red-legged Frog and the Sharp-tailed Snake. The former has never been found in the marsh either year. Probably the dry summer period in the marsh precludes its being a resident, but it could still be a winter visitant. Its potential presence is of considerable interest, since it is the principal food of the San Francisco Garter Snake. Some experts believe that the snake migrates looking for this special food source.

The Sharp-tailed Snake is found along the edges of water in fields and grasslands; thus, it could be present in the marsh area. However, no sightings of the snake have been made in either year. It is considered to be a rare resident.

While there is no legal protection for birds on the Blue List presently, the fact that 14 such species are found in the marsh indicates the importance of such an area in maintaining species which are showing some difficulties of survival. Of the 14 species sighted in 1975, only 4 were sighted in 1976. At least one female Marsh Hawk was much in evidence harrying both the fresh and saltwater zones. The American Kestrel is well represented in the area (perhaps 3-5 residents). Bewick's Wren is a common resident in the willows, the Loggerhead Shrike is a common winter visitant to the scrub, and the Lesser Goldfinch is an uncommon resident of the freshwater marsh and grasslands.

There are no known endangered or rare plant species in the area (SMCo, 1976).

METHODS AND DATA REPORTING

Transect establishment - The basic approach used for studying the marsh is the transect method. Transects were layed out along the principal hydrologic and salinity gradients. To conserve on time and manpower, we also established a number of key spot locations around other parts of the marsh, rather than establish too many transects. Vegetation sampling has been carried out along the transects, soil sampling both along the transects and at spot locations. Animal surveys, trap and drop board lines have been layed out partly along the transect lines, but also to cover the most important habitat areas and the ecotonal areas. The following transects have been established (Figs. 6-10):

Transect A- freshwater marsh along moisture-salinity gradient northward

Transects B, C, & D - freshwater marsh along moisture-salinity gradient in the northeast lobe of the marsh

Transects E & F - saltwater marsh across ecotonal boundaries

Transects L & M - freshwater marsh along moisture gradient at far north end

Vegetation - the distribution of the vegetation was determined in terms of frequency and an estimate of the percent cover. Frequency was obtained by observing the plant species intercepting each foot interval of the transects. A band approximately 2" wide each side of the transect tape was included in order to allow for variation in the tape position between different measurements. The data reported here is in terms of frequency, i. e., the number of 1 ft. intervals in which a given species appears per larger interval of 25 ft. In addition, percent cover class (0-30, 30-60, and 60-100%) was estimated for each 1 ft. interval, with the aid of the inch marks on the tape. Using weighting factors (1, 2, and 4, respectively), one can convert the foregoing information to an estimate of the percent cover of each species. Both types of data indicate where vegetational boundaries lie along the environmental gradients. In addition, color aerial photography is being used to observe movement of the boundaries, and of the moisture zones.

In connection with the soil sampling, the underground vegetative parts are being observed qualitatively in order to detect moisture responses. The presence of bulbs, rootstocks, etc., in the topsoil are noted as evidence of the recent movement of vegetational boundaries. During the monitoring phase, all of the vegetational parameters will continue to be measured.

Soils - sampling has been carried out along the transects (except E & F) and at spot locations. Transect sampling intervals average around 100 ft. Sampling was accomplished with a barrel auger, generally at depth intervals of 0-4 in. and 20-24 in. Soil moisture was determined gravimetrically (dry weight basis), Soil fauna was estimated qualitatively in the field. Soil salinity was determined on selected samples by electrical conductivity measurements on 1:1 aqueous extracts. Monitoring will continue the measurement of the foregoing parameters. Initial detailed profile descriptions of the principal soils have been made, including texture, color (both determined in the field), and buried plant parts.

Animals - most of the animal studies have been aimed at estimating relative densities of those species believed to be most indicative of moisture conditions. The can traps consisted of gallong-size cans sunk in the ground flush with the surface. They were designed to catch shrews, newts and salamanders, and surface-crawling insects and spiders. The drop boards consist of 12"x12" plywood boards laid on the ground to collect the pellets of small vertebrates, show footprints (when covered with a coating of dust), and to afford shelter for invertebrates underneath. Sherman live traps for small vertebrates have been used to a limited degree (about 100 trap-nights so far).

As time has permitted, sightings of any species have been recorded according to habitat areas delineated on the map of the entire marsh. If sufficient data can be collected over a period of time, at least for certain species, it may be possible to estimate densities and density changes between habitats and over time. The measurement of all animal parameters is being continued during monitoring.

Hydrology - water table levels are being measured frequently along the transects and at spot locations. During the wet period, soil sampling holes (2 ft. or less in depth), and soil auger probings have generally sufficed. However, for more accurate determinations, in order to avoid perched water tables, and for measuring during the dry season, we are currently installing plastic pipes to 5 ft. below the surface. Marsh water table data is being correlated with the well monitoring hole data. The main sampling points are given in Fig. 5.

Mapping & Surveying - in general, we have used the County of San Mateo's combined aerial-base map of the Fitzgerald Marine Reserve (Sheet 2), March, 1976, at a scale of 1" = 200' as our base map. A ground survey was run of the freshwater marsh section, using a theodolite, in December of 1976. Only relative elevations were obtained on this survey. The survey contours were compared on the map with the aerial contours (5 ft. contour interval), and it is believed that the elevations given are accurate within ±0.25 ft.

Color aerial photography of the marsh was started in December, 1976, using a regular 35 mm. camera and shooting from a light plane at elevations of 1,000 and 2,000 ft. Sequential pictures will be taken every one to two months in order to follow the vegetational and moisture changes in the marsh.

TABLE I. SPECIES LIST OF PLANTS

(FAMILY) Scientific Name	Common Name	Moisture-Salinity Tolerance
ASPIDIACEAE		
Athyrium Felix-femina var. *sitchensis*	Lady Fern	M
Polystichum munitum	Sword Fern	M
CAPRIFOLIACEAE		
Lonicera involucrata	Twinberry	M
Sambucus callicarpa	Red Elderberry	M
CHENOPODIACEAE		
Atriplex patula ssp. *hastata*	Fat Hen	S
Salicornia virginica	Pickleweed	S
COMPOSITAE		
Achillea borealis ssp. *arenicola*	Yarrow	D
Anaphalis margaritacea	Pearly Everlasting	
Artemisia Douglasiana	Sagebrush	
Aster chilensis	Common California Aster	M
Baccharis pilularis	Coast Baccharis	
B. pilularis ssp. *consanguinea*	Coyote Brush	
Cirsium vulgare	Bull Thistle	D
Conyza canadensis	Horseweed	D, M
Erectithes prenanthoides	Fireweed	D, M, B
Eriophyllum staechadifolium var. *artemisiaefolium*	Golden Yarrow	B
Grindelia stricta ssp. *venulosa*	Gum-plant	B
Helenium puberulum	Sneezeweed	M
Hypochoeris radicata	Cat's Ear	M
Jaumea carnosa	Fleshy Jaumea	S
Picris echioides	Bristly Ox Tongue	D
Senecio mikanioides	German Ivy	M
Silybum Marianum	Milk Thistle	D
Solidago canadensis ssp. *elongata*	Meadow Goldenrod	M
Sonchus oleraceus	Common Sow Thistle	D, M
CONVULVULACEAE		
Convulvulus arvensis	Bindweed	D
CORNACEAE		
*Cornus stolonifera**	American Dogwood	M

CRUCIFERAE

Brassica campestris	Common or Field Mustard	D
Cakile maritima	Sea Rocket	S
Raphanus sativus	Wild Radish	D, B

CUPRESSACEAE

Cupressus macrocarpa	Monterey Cypress	

CYPERACEAE

Carex obnupta	Slough Sedge	M
Scirpus californicus	California Tule or Bulrush	W, B
S. microcarpus	Panicled Bulrush	W
S. robustus	Prairie Bulrush	M, B

EQUISETACEAE

Equisetum Telmateia	Giant Horsetail	M

FRANKENIACEAE

Frankenia grandifolia	Alkali Heath	S

GERANIACEAE

Geranium dissectum	Cut-leaved Geranium	D, M

GRAMINEAE

Avena fatua	Wild Oat	D
Bromus mollis	Soft Chess	D
B. rubens	Foxtail Chess	D
Distichlis spicata var. *stolonifera*	Salt Grass	S
Elymus triticoides	Wild Rye	B
Holcus lanatus	Velvet Grass	D

JUNCACEAE

Juncus effusus var. *brunneus*	Bog Rush	M
J. effusus var. *pacificus*	Bog Rush	M
J. Lesueurii	Salt Rush	M, B
J. patens	Spreading or Common Rush	M

LABIATAE

Mentha arvensis (2 forms?)	Marsh Mint	M
Satureja Douglasii	Yerba Buena	M

LEGUMINOSAE

Medicago hispida	Bur-clover	D
Lotus corniculatus	Bird's Foot Trefoil	D
Lupinus Chamissonis	Bush Lupine	B
Vicia benghalensis	Vetch	M

MALVACEAE		
Malva nicaeensis	Bull Mallow	D
MYRICACEAE		
Myrica californica*	California Wax-myrtle	M
ONAGRACEAE		
Epilobium Watsonii var. franciscanum	San Francisco Willow Herb	M
PLANTAGINACEAE		
Plantago coronopus	Cut-leaved Plantain	B, D
P. lanceolata	Ribwort	D
POLYGONACEAE		
Polygonum punctatum	Water Smartweed	B, M
P. coccineum	Swamp Knotweed	W
Rumex fenestratus	Dock	B, M
R. crispus	Curly Dock	D, M
R. transitorius	Sorrel	M
PRIMULACEAE		
Anagallis arvensis	Pimpernel	D, M
PTERIDACEAE		
Pteridium aquilinum	Bracken Fern	
RHAMNACEAE		
Rhamnus californica	Coffeeberry	
ROSACEAE		
Horkelia californica	California Horkelia	
Potentilla Egedii var. grandis	Pacific Silverweed	W, B
Rubus ursinus	California Blackberry	D, M
RUBIACEAE		
Galium aparine	Bedstraw	M, D
G. trifidum var. subbiflorum	Bedstraw	M
SALICACEAE		
Salix lasiolepis	Arroyo Willow	W, B?
S. Coulteri	Velvet Willow	W
SCROPHULARIACEAE		
Mimulus guttatus	Yellow Monkey Flower	W
Scrophularia californica	California Bee Plant	
SOLANACEAE		
Solanum nodiflorum	Small-flowered Nightshade	M

SPARGANIACEAE

Sparganium eurycarpum	Broad-fruited Burreed	W
TYPHACEAE		
Typha latifolia	Broad-leaved Cat-tail	W, B
T. angustifolia	Nail Rod	W
T. glauca	Blue-flag	W
UMBELLIFERAE		
Apium graveolens	Celery	D, M
Cicuta Douglasii	Water-Hemlock	W
Conium maculatum	Poison Hemlock	D
Daucus pucillus	Rattlesnake Weed	D
Foeniculum vulgare	Sweet Fennel	D
Oenanthe sarmentosa	Pacific Oenanthe	W
URTICACEAE		
Urtica holosericea	Stinging Nettle	M

M - moist
W - wet
B - brackish
S - saline
* - single plant observed

TABLE II. SPECIES LIST OF ANIMALS

This list is restricted to the vertebrate species found in the marsh during November and December of 1976.

Species	Habitat G '76	G '75	FWM '76	FWM '75	SWM '76	SWM '75	StW '76	StW '75	W '76	W '75	CS '76	CS '75
Brush Rabbit *Sylvilagus Bachmani*		cR	cR	cR	uR	cR			cR		cR	cR
Western Harvest Mouse *Reithrodontomys megalotis*		cR	uR	uR								uR
Deer Mouse *Peromyscus maniculatus*		cR	uR	cR		cR			uR		uR	cR
Dusky-footed Woodrat *Neotoma fuscipes*				cR					cR			

Species	Habitat: G '76	G '75	FWM '76	FWM '75	SWM '76	SWM '75	StW '76	StW '75	W '76	W '75	CS '76	CS '75
California Vole *Microtus californicus*	uR	aR	uR	aR		aR			uR		uR	aR
Racooon *Procyon lotor*		uR		uR		uV			uR		uR	cR
Long-tailed Weasel *Mustela frenata*		cR		cR	uR	cR					uR	cR
Domestic Cat *Felis cattus*	cV	cV	cV	cV	uV	cV			cV		cV	cV
Pintail *Anas acuta*						uWV	uWV					
Northern Shoveler *Anas clypeata*						cWV	uWV					
Bufflehead *Bucephala albeola*						cWV	uWV					
Turkey Vulture *Cathartes aura*		cR		cR								cR
White-tailed Kite *Elanus leucurus*	cWV	uMSF WV	cWV	uMSF WV	uWV	uMSF WV			cWV		cWV	uMSF WV
Red-tailed Hawk *Buteo jamaicensis*	aR	cR	cR	cR					cR		cR	cR
Marsh Hawk *Circus cyaneus*	cWV	cWV	aWV	cWV	aWV	cWV			cWV		cWV	cWV
American Kestrel *Falco sparverius*	aR	cR	cR	cR		cR					cR	cR
American Coot *Fulica americana*				cWV		cWV	aWV					
Killdeer *Charadrius vociferus*		cR		cR	uR	cR						
Willet *Catoptrophorus semipalmatus*						cMSF WV	uWV					
Northern Phalarope *Lobipes lobatus*						rMSF WV	cWV					
Mourning Dove *Zenaida macroura*	uR	cR							uR		uR	
Great Horned Owl *Bubo virginianus*				uR					uR			

Species	Habitat											
	G		FWM		SWM		StW		W		CS	
	'76	'75	'76	'75	'76	'75	'76	'75	'76	'75	'76	'75
Anna's Hummingbird *Calypte anna*		cR		cR		cR			aR		cR	cR
Common Flicker "Red-shafted" *Colaptes auratus*	uR	cR		cR		cR			uR		uR	cR
Black Phoebe *Sayornis nigricans*		cMSF WV	cWV	cMSF WV	cWV	cMSF WV			uWV		cWV	cMSF WV
Chestnut-backed Chickadee *Parus rufescens*		cR		cR					cR		uR	cR
Bushtit *Psaltriparus minimus*	cR	cR		cR		cR			aR		aR	cR
Bewick's Wren *Thryomanes Bewickii*		uR		uR					cR		uR	uR
Long-billed Marsh Wren *Telmatodytes palustris*			aR	cR	aR	cR						
Golden-crowned Kinglet *Regulus satrapa*				cMSF WV					uWV			
Ruby-crowned Kinglet *Regulus calendula*				cMSF WV					cWV			
Loggerhead Shrike *Lanius ludovicianus*		uMSF WV				uMSF WV					cWV	uMSF WV
Starling *Sturnus vulgaris*	cR		uR	uR		uR						
Yellowthroat *Geothlypis trichas*			cR	cR	cR	cR						
Western Meadowlark *Sturnella neglecta*	aR	cR	cR		cR						cR	cR
Red-winged Blackbird *Agelaius phoeniceus*	aWV		cWV	cWV SuV	cWV	cWV SuV			cWV		uWV	
Brewer's Blackbird *Euphagus cyanocephalus*	aWV	cMSF WV	cWV	cMSF WV	cWV	cMSF WV			cWV		uWV	cMSF WV
House Finch *Carpodacus mexicanus*	cR	aR		aR		aR			cR		cR	aR
Lesser Goldfinch *Spinus psaltria*	uR	uR	uR	uR		uR						uR
Brown Towhee *Pipilo fuscus*		cR		cR					uR		uR	cR

Species	G '76	G '75	FWM '76	FWM '75	SWM '76	SWM '75	StW '76	StW '75	W '76	W '75	CS '76	CS '75
White-crowned Sparrow <u>Zonotrichia</u> <u>leucophrys</u>		cR	aR	cR	cR	cR			cR		aR	cR
Golden-crowned Sparrow <u>Zonotrichia</u> <u>atricapilla</u>		cWV	uWV	cWV							uWV	cWV
Fox Sparrow <u>Passarella</u> <u>iliaca</u>		cWV	cWV	cWV					aWV		uWV	cWV
Song Sparrow <u>Melospiza</u> <u>melodia</u>		cR	aR	cR		cR			cR		uR	cR
Common Goldeneye <u>Bucephala</u> <u>clangula</u>							uMSF					
Yellow-eyed Salamander <u>Ensatina</u> <u>Escholtzi</u> <u>xanthoptica</u>	uR	uR	uR	uR					uR			
California Slender Salamander <u>Batrachoseps</u> <u>attenuatus</u>	uR	uR										cR
Pacific Treefrog <u>Hyla</u> <u>regilla</u>		cR	aR	aR								cR
Coast Garter Snake <u>Thamnophis</u> <u>elegans</u> <u>terrestris</u>		aR	cR	aR		aR					cR	aR

<u>Habitat</u>

G - Grassland
FWM - Freshwater Marsh
SWM - Saltwater Marsh
StW - Standing Water (in SWM)
W - Willows
CS - Coastal Scrub (Baccharis community)

<u>Abundance</u>

a - abundant, c - common, u - uncommon (observed only once or several times), r - rare (found in residual numbers - applies to '75 only)

<u>Status</u>

R - resident, M - migrant, S - spring, F - fall, SuV - summer visitant (may be present May-September), WV - winter visitant (may be present September-April)

'75 - refers to the Fitsgerald Marine Reserve EIR (1976)
'76 - refers to this study during November-December of 1976.

VEGETATION

Dominant Species
(Continued)

Juncus effusus	Je
Juncus Lesueurii	Jl
Polygonum coccineum	Pc
Polygonum punctatum	Pp
Rubus ursinus	Ru
Salix Coulteri	Sc
Salix lasiolepis	Sl
Sparganium eurycarpum	Se
Salicornia virginica	Sv
Typha complex	T
Typha angustifolia	Ta
Typha glauca	Tg
Typha latifolia	Tl
Urtica holosericea	Uh

ANIMALS

Can traps

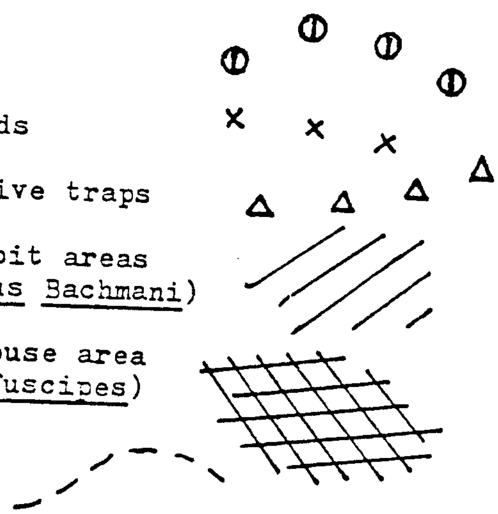
Drop boards

Sherman live traps

Brush Rabbit areas
(*Sylvilagus Bachmani*)

Woodrat house area
(*Neotoma fuscipes*)

Foot trail



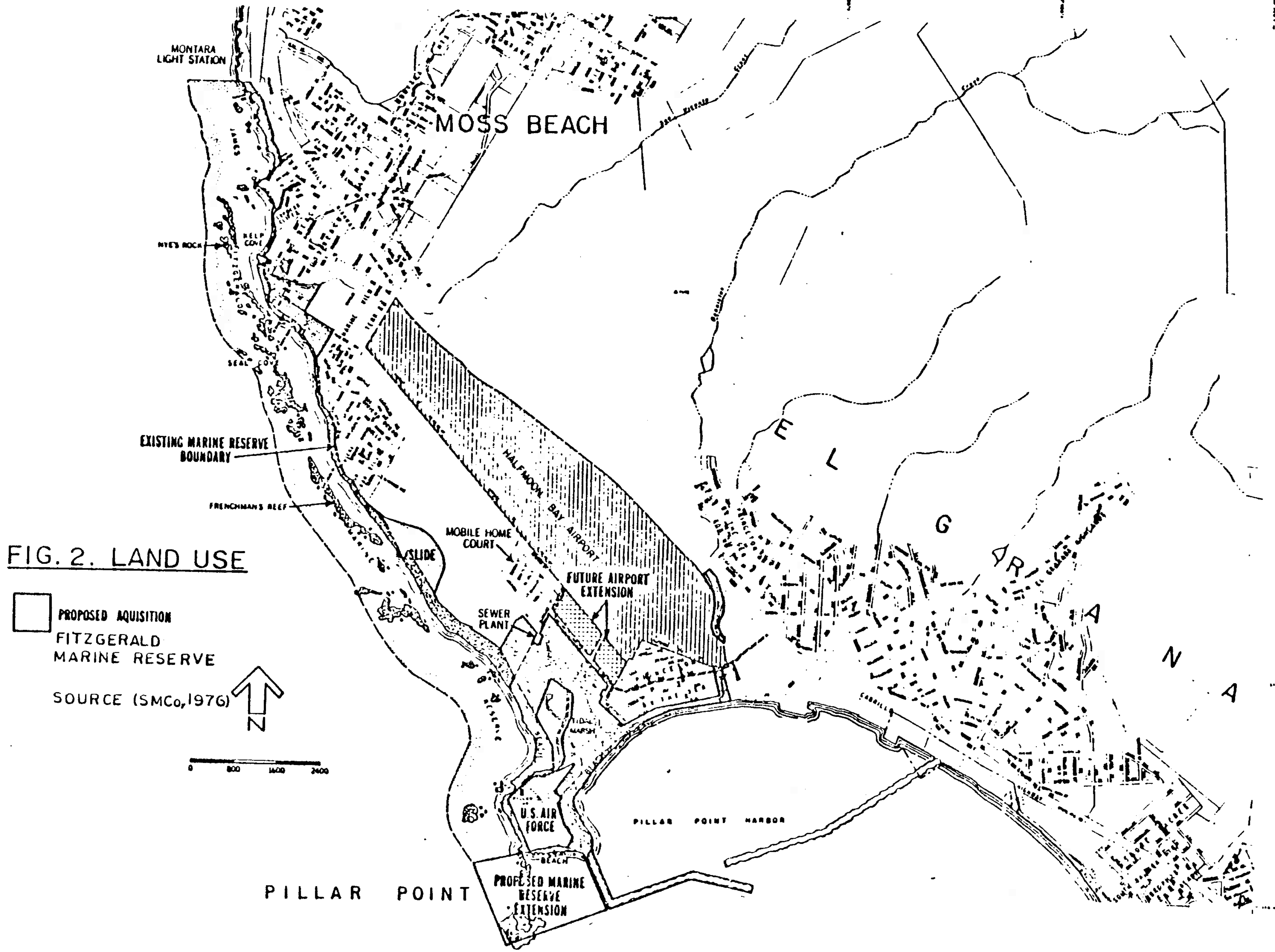
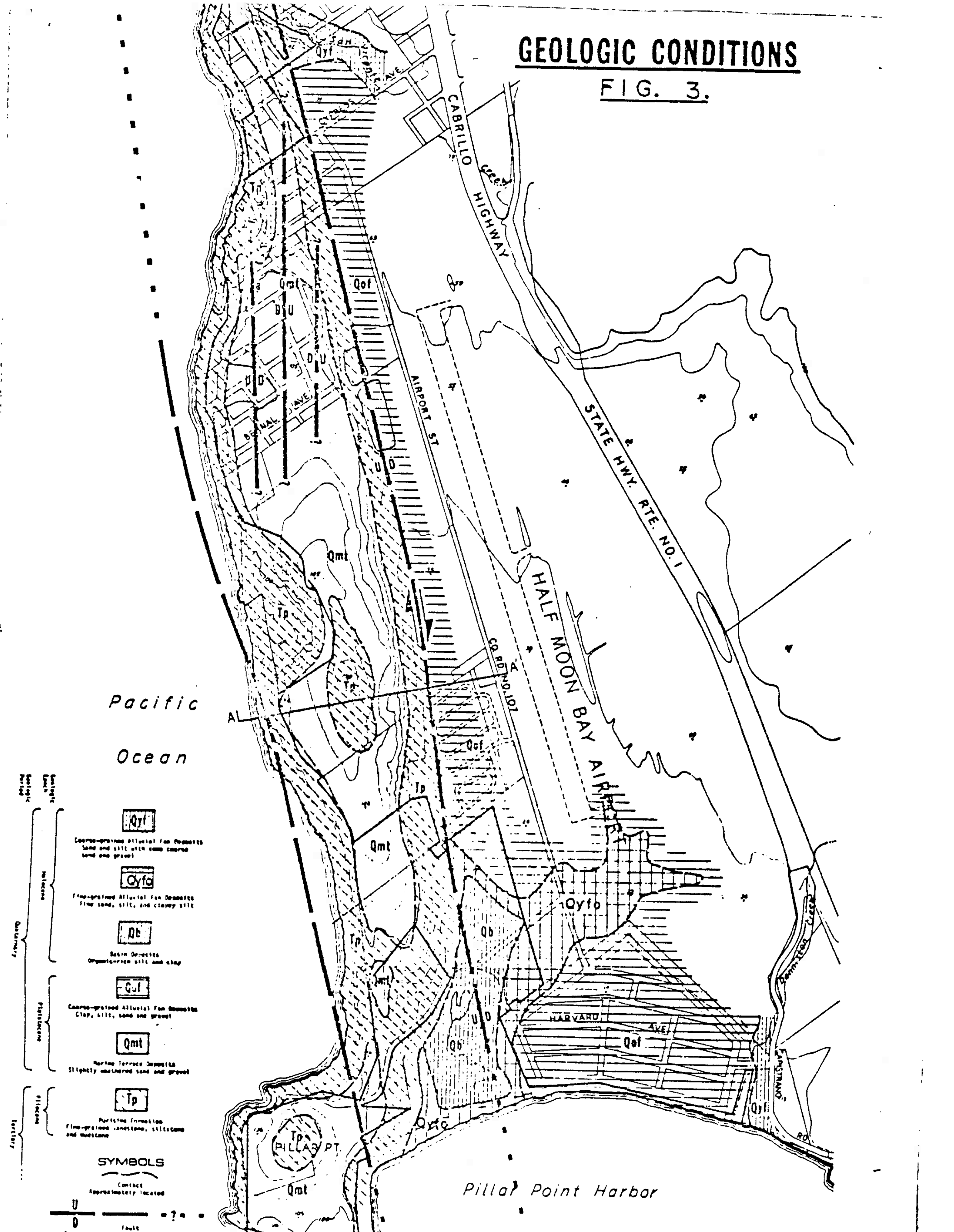


FIG. 2. LAND USE

GEOLOGIC CONDITIONS

FIG. 3.



SOURCES: (SMCo, 1976)

Lajoie, 1975; Lajoie and others, 1974; Leighton and Associates, 1971; Lowney-Kaldveer Associates, 1976.

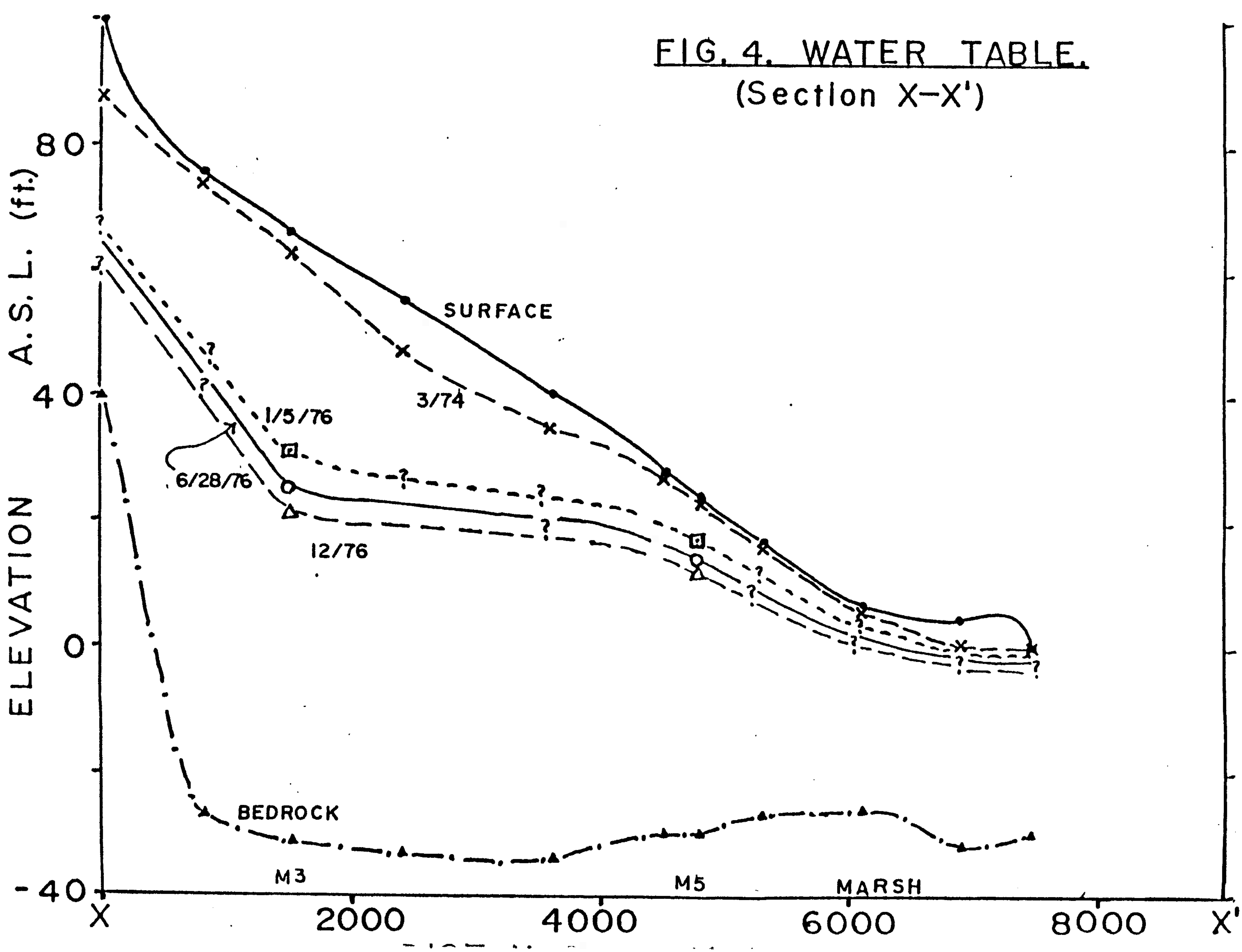


FIG. 4. WATER TABLE.
(Section X–X')
SURFACE
3/74
1/5/76
6/28/76
12/76
BEDROCK
M3
M5
MARSH
ELEVATION A.S.L. (ft.)
80
40
0
-40
X
2000
4000
6000
8000
X'

FIG. 6. TRANSECTS A & M

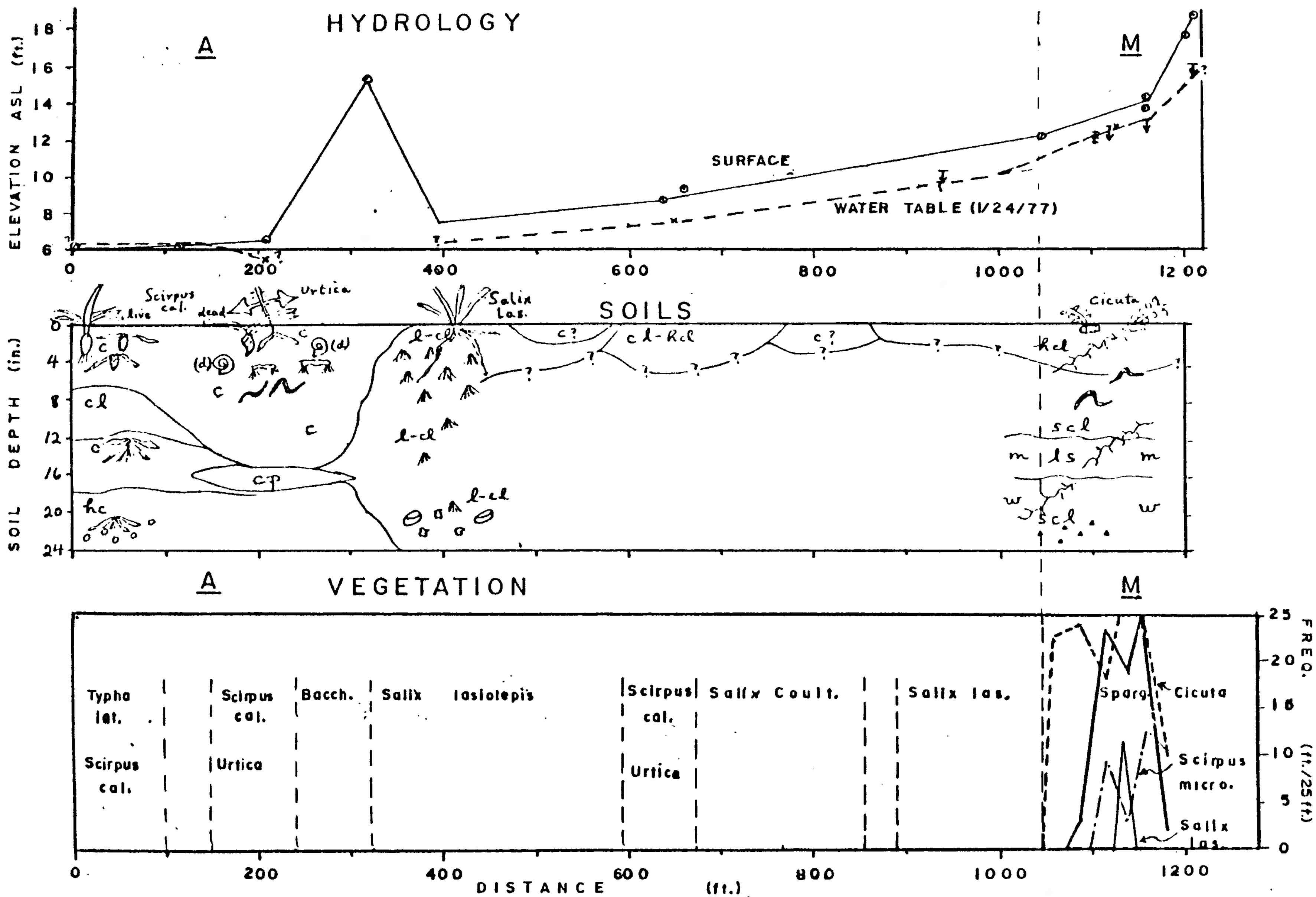


FIG. 10. TRANSECTS E & F

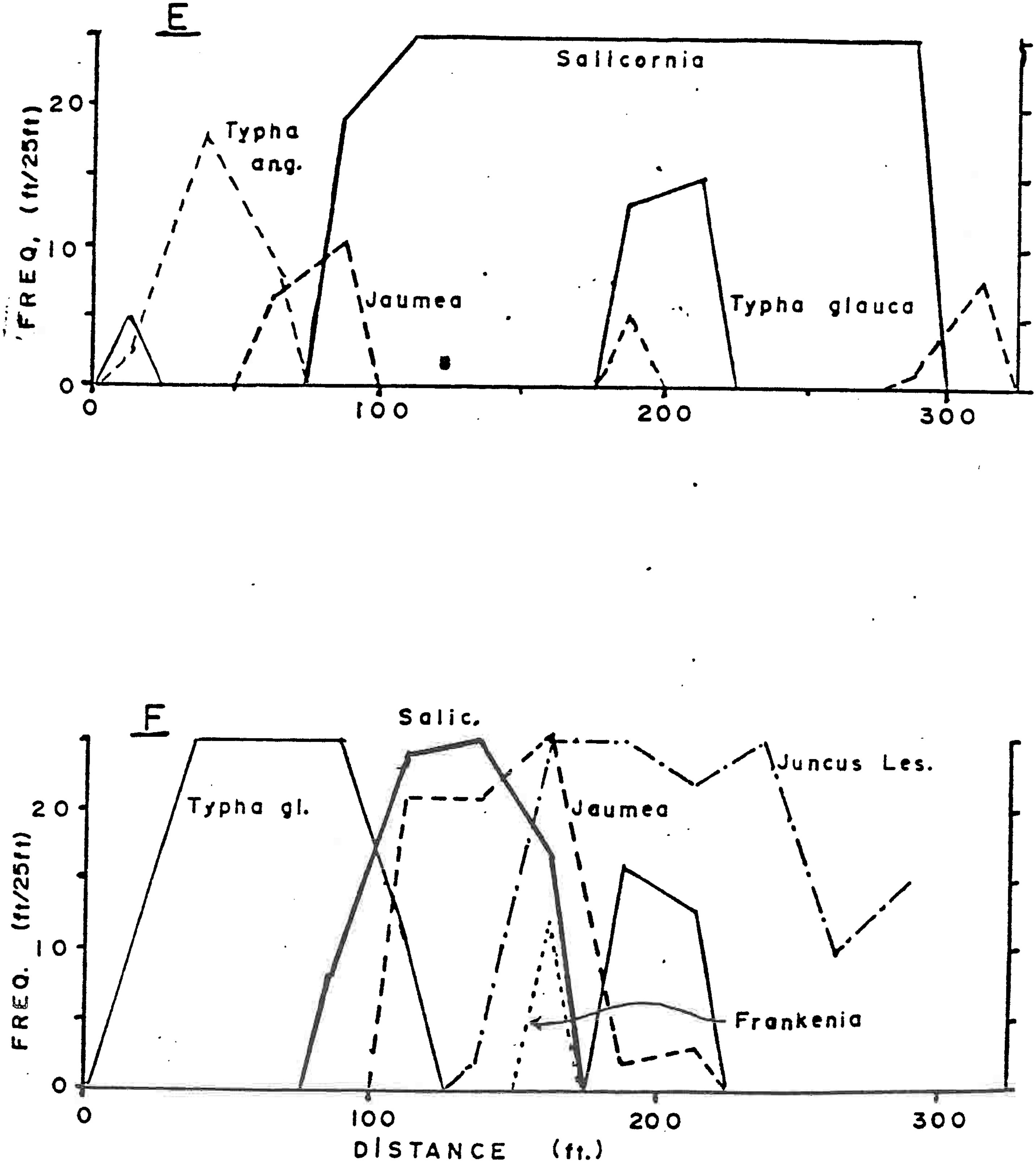


FIG. II. VEGETATION

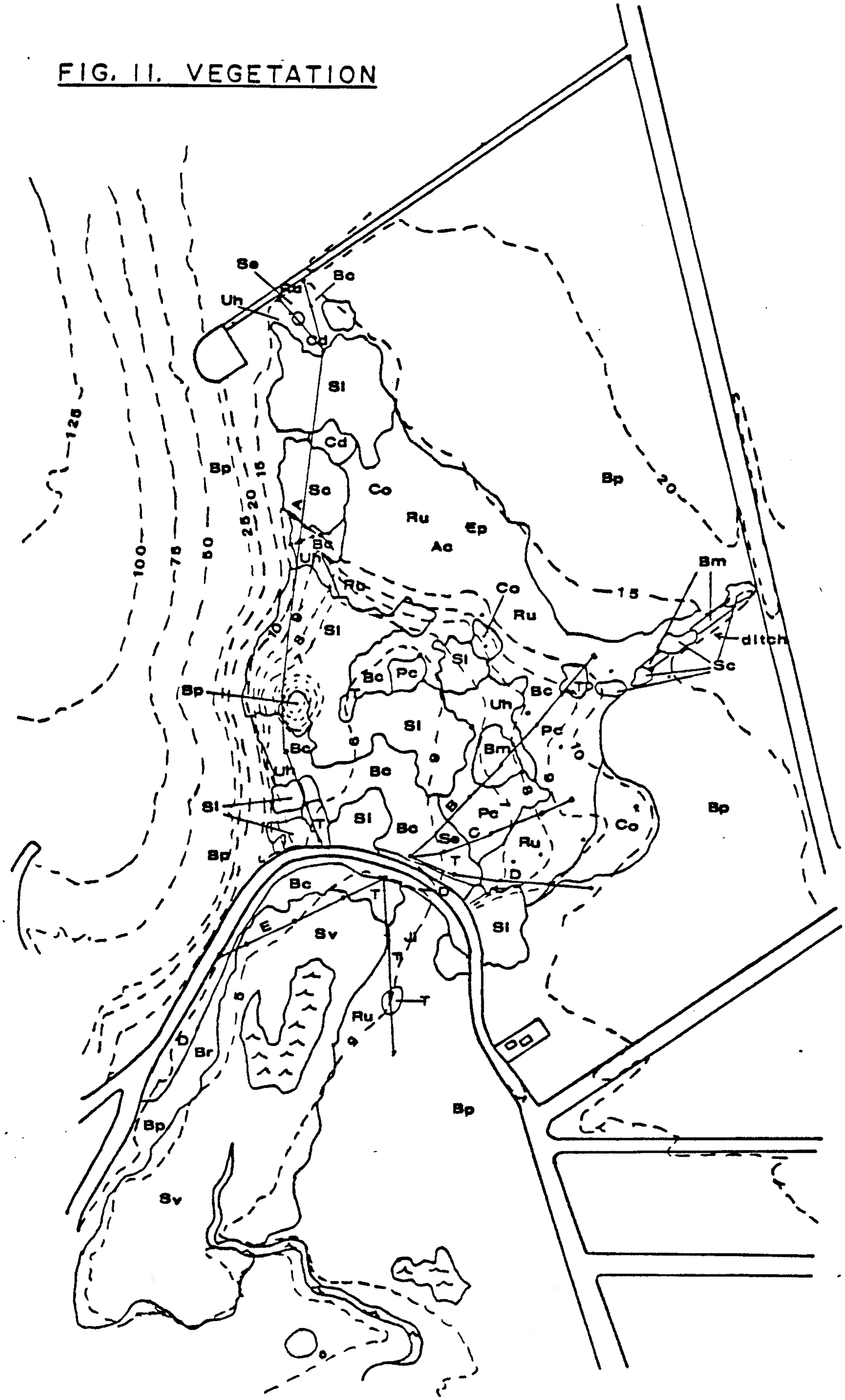


FIG. 12. VEGETATION (detail)

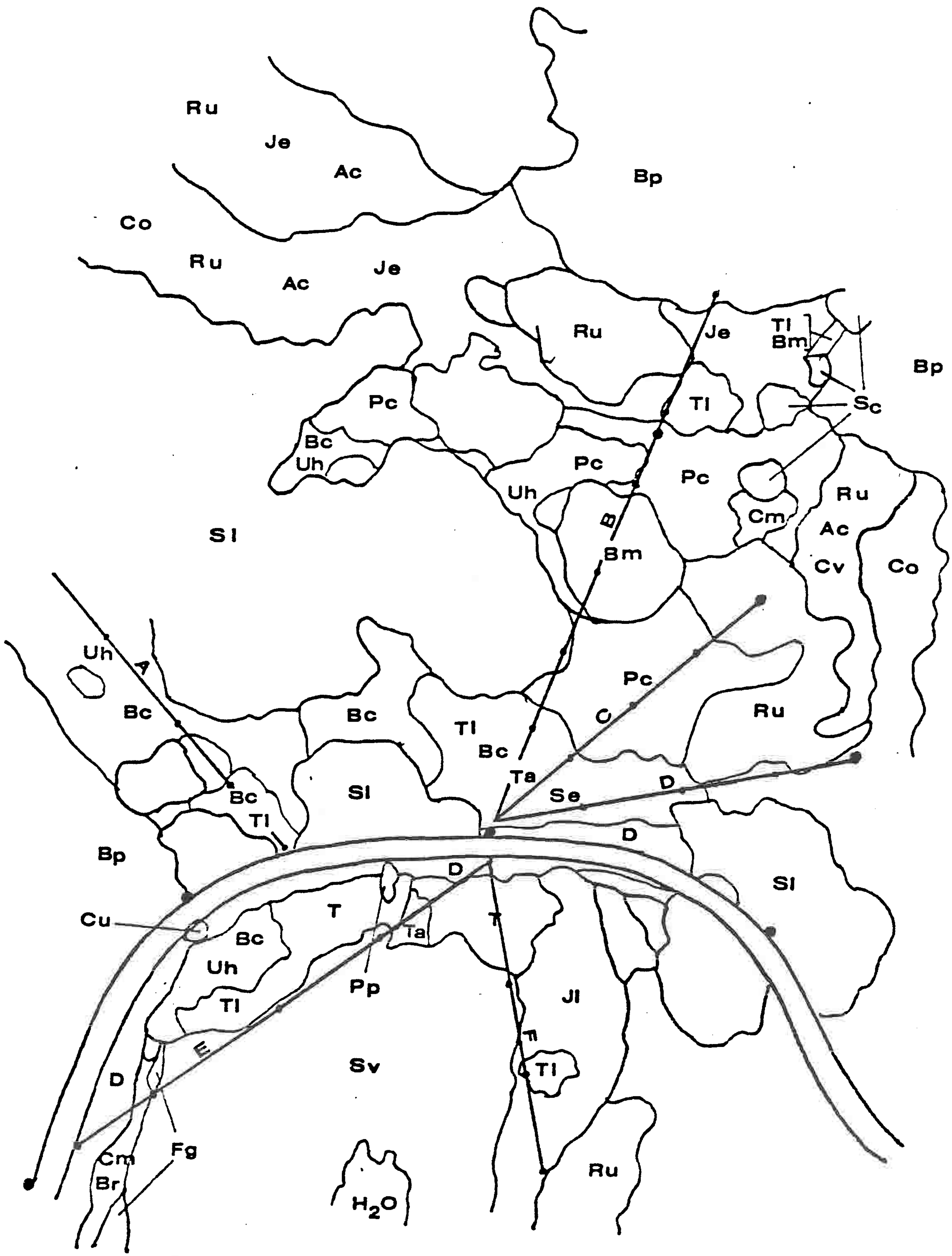
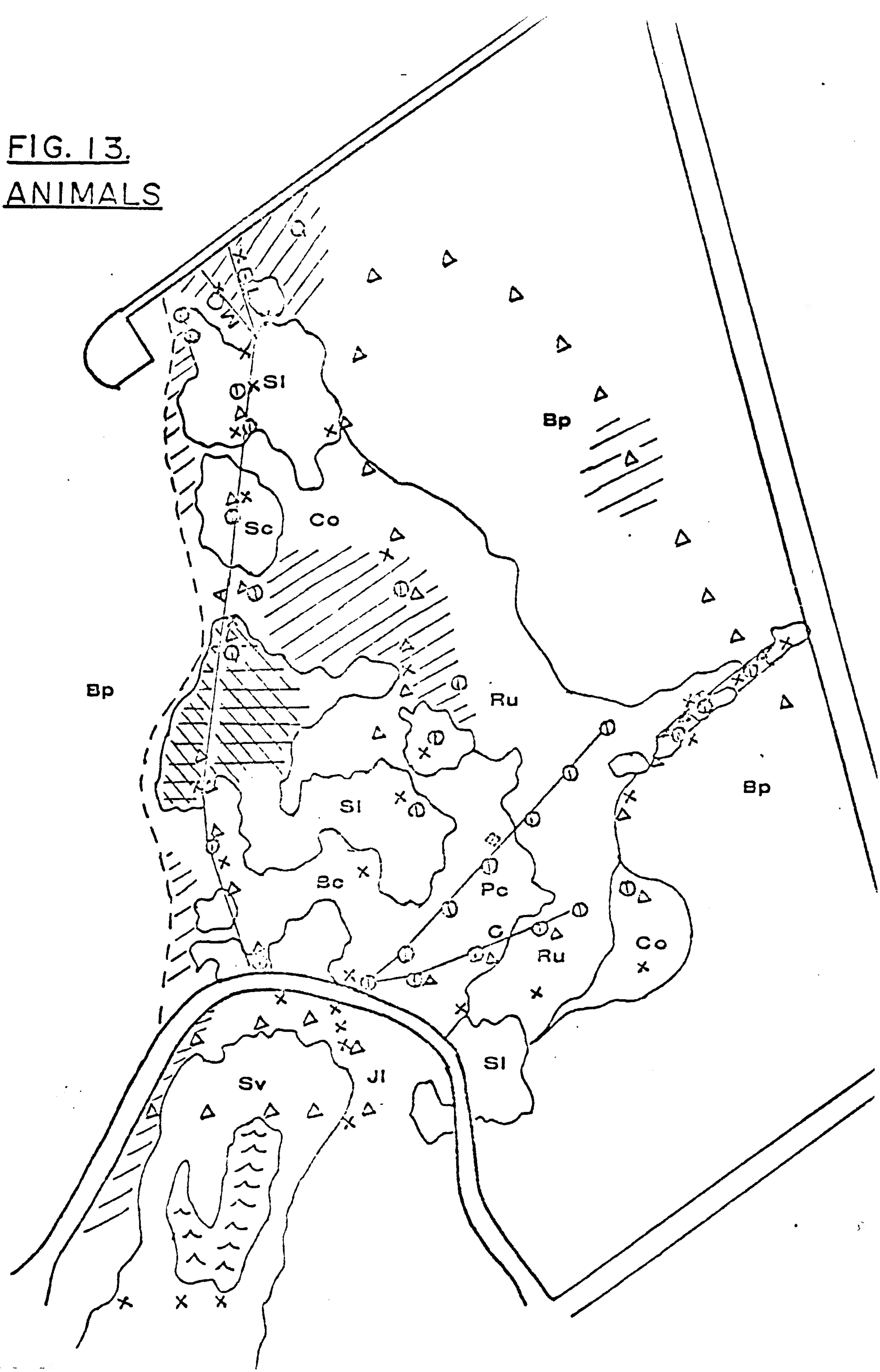


FIG. 13.
ANIMALS



LEGEND FOR MAPS AND GRAPHS

SOIL PROFILES

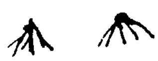
Soil textures

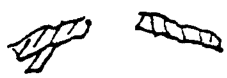
coarse sand	cos
sand	s
clayey sand	cs
loamy sand	ls
loam	l
clay loam	cl
sandy clay loam	scl
heavy clay loam	hcl
clay	c
heavy clay	hc
clay pan	cp

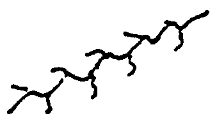
Textural boundary 

Roots

Polygonum cocc. (red woody roots) 

fine roots (usually *Scirpus*, live or dead) 

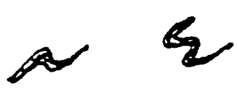
coarse roots (dead) 

old fine root channels (filled with red material, *Scirpus*?) 

Leaves (buried, *Scirpus*) 

Charcoal 

Soil invertebrates

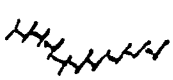
earthworms 

snails (dead) 

Mineral components

specks of decomp. granite (white or yel.) 

gravel 

clay pan 

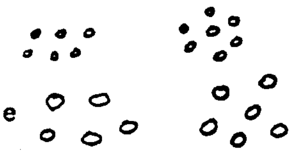
SOIL PROFILES (Continued)

Mottling

faint prominent

fine

coarse

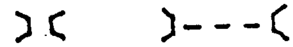


HYDROLOGY

Stream 

Drainage ditch 

Marsh 

Culvert 

Shoreline 

VEGETATION

Transect and sampling points 

Contour 

Power pole 

Vegetation boundary 

Dominant species

Aster chilensis	Ac
Scirpus calif.	Bc
Scirpus micro.	Bm
Baccharis pil.	Bp
Brassica camp.	Br
Cicuta Doug.	Cd
Conium mac.	Cm
Carex obnupta	Co
Cupressus macr.	Cu
Cirsium vulg.	Cv
Disturbed	D
Erechtites pre.	Ep
Frankenia grand.	Fg

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