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AQUATIC LANDS DEFINITION STUDY

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

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FOR

DEPARTMENT OF ECOLOGY
STATE OF WASHINGTON
CONTRACT 77-054

BY

NORTHWEST ENVIRONMENTAL CONSULTANTS
219 MADISON AVENUE SOUTH
BAINBRIDGE ISLAND, WASHINGTON 98110

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PREFACE

This report documents the second phase of a research project designed to define the boundaries of Washington State aquatic lands.

In 1971 the Washington State Legislature passed the Shoreline Management Act, which was approved by the voters in the elections of 1972. The passage of this act gave cities and counties, along with the State Department of Ecology, responsibilities for long-range shoreline land-use planning and also for acting on permit requests involving substantial shoreline development.

The State's role in the Shoreline Management Act has been incorporated into the Coastal Zone Management Program, a program developed in response to a Federal law, the Coastal Zone Management Act of 1972 (P.L. 92-583). As a part of the development and administration phases of the program, the Department of Ecology has conducted or funded a number of studies to provide basic information regarding shorelines which can be used as management tools. Local governments have also undertaken similar projects.

In developing management tools to implement the Shoreline Management Act and the Coastal Zone Management Program, it has become necessary for the regulating agency, the Department of Ecology, to define and determine the boundaries of areas that are within the jurisdiction of the programs. One such boundary is the upper boundary of aquatic lands of the State.

The Department of Ecology, in pursuing its obligations under the Coastal Zone Management Program, has initiated a phased research project directed at formulating a definition of the boundaries of aquatic lands. The first phase of this research project has been completed (NEC, 1976) and certain recommendations were made which resulted in the development of the second phase involving field research on the recommendations.

ACKNOWLEDGMENTS

This study was conducted under the direction of Dr. David Jamison and Fred Gardner of the Department of Ecology. NEC staff involved included Thomas Backman (principal investigator), Bob Franklin, Ron Vanbianchi, Martha Knappe, Douglas Canning, and Andy Driscoll with assistance from Roats Engineers and Surveyors. Special thanks goes to Dr. Ronald Phillips for his help in critically evaluating all phases of the project.

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INTRODUCTION

INTRODUCTION

This report presents the results of field investigations which were conducted to determine the scientific validity of four proposed alternative definitions (NEC 1976) of the upper boundary limit (ULM) of Washington State Aquatic Lands. Also investigated, was the possibility of re-wording the definition to better conform with the empirical data gathered.

The original definition developed by NEC (1976) was based on a review of the scientific literature and existing legal definitions from other state and government documents, plus consultation with the scientific community. The NEC report recommended a tentative definition for the coastal wetlands of the State of Washington as follows:

> "Any area under or intermittently covered by waters which rise and fall due to tidal action, up to the line of local extreme high water, or any area contiguous to and strongly influenced by waters which rise and fall due to tidal action."

The NEC report recognized that the phrase "strongly influenced" was open to interpretation and that guidelines would have to be developed for applying the definition and interpreting which areas might be "strongly influenced" by tidal waters. Four alternative guidelines were developed and recommended for further investigation:

Alternative One: Areas below an elevation of one foot above Extreme High Water (EHW).

Alternative Two: Areas denoted by the presence of one or more of the following plant species:

Rumex maritimus (Seaside dock)
Salicornia virginica (Pickleweed)
Spergularia canadensis (Sand spurry)
Glaux maritima (Milkwort)
Plantago maritima (Seaside plantain)
Jaumea carnosa (Jaumea)
Triglochin maritimum (Arrowgrass)
Juncus balticus (Baltic rush)
J. falcatus (Sickle-leaved rush)
J. lesueurii (Saltrush)
Distichlis spicata (Saltgrass)
Puccinellia maritima (Alkali grass)
Potentilla anserina (Common silverwood)
P. pacifica (Pacific silverwood)
Scirpus spp.
Typha latifolia (Cattail)
Lilaeopsis occidentalis (Lilaeopsis)
Carex lyngbyei (Sedge)
Fucus distichus (Rockweed)
Ulva spp. (Lettuce weed)
Navicula spp. (Diatom)

Dermocarpa sp. (Blue-green algae)
Pleurocapsa (Blue-green algae)
Lyngbya (Blue-green algae)
Enteromorpha sp. (Green algae)
Ectocarpus sp. (Brown algae)

Alternative Three: Areas where ground water rises and falls due to tidal action.

Alternative Four: Areas which have an interstitial soil salinity greater than or equal to two parts per thousand.

The term "aquatic lands" is a very general one. Used in association with the four proposed alternative definitions, it is effectively limited to marine influenced aquatic lands. Within the category of marine influenced aquatic lands the upper boundary limit (ULM) of intertidal marshes is considered the most difficult to determine and also of prime concern for environmental management. Therefore the Department of Ecology determined that intertidal marshes would be the focus of this study.

The marine marshes can be thought of as island habitats whose community structure is dependent upon local species extinction, and immigration of species from other marshes. The sum results of these processes are indicative of the complex coastal marsh ecosystems (which are dependent upon the waters, air born seeds, and migratory species to keep the system viable) upon which the definition may be based.

The approach to testing these alternatives was to sample representative marshes in Puget Sound and the Strait of Juan de Fuca region of Washington. The sites were selected and the stratified random sampling methods to be employed were pre-tested to insure that scientifically valid and statistically significant results would be obtained. The methods and site selection criteria were developed in cooperation with the Department of Ecology staff and are presented in the Methods and Materials Section.

The current coastal zone management literature was reviewed to identify similar, recently completed and ongoing studies directed at defining coastal and estuarine zone wetland boundaries, the appropriate literature being cited throughout this report. Of particular note is an investigation currently being conducted by the Environmental Protection Agency of coastal wetlands in the Pacific outer coast of Washington (Hal Kippy, personal communication).

The Results section summarizes the field data, with complete descriptions of each site area presented in Appendix I. Appendix I also includes site maps and site-specific raw data.

The discussion of the data is presented in a statistically generalized manner to avoid the inherent anomalies present in site-specific data summaries.

The analysis of the tidal data cannot be completed until all of the tidal elevation data is available.

METHODS AND MATERIALS

METHODS AND MATERIALS

Site Selection

Prior to the selection of sites, a set of criteria was developed as an aid to assure that the sites under investigation would be suitable for the intended purpose. "Primary criteria" were those criteria considered to be essential characteristics for each site. "Secondary criteria" were employed only when it was necessary to select between two or more potential sites meeting all the primary criteria.

Primary Criteria:

1. Sites must be located in Washington State.
2. Waters contiguous to the site must rise and fall due to tidal action. (Criterion must be met as per the definition).
3. Sites must be in close proximity to an existing tidal benchmark or where a tidal gauge can be installed. (This criterion must be met in order to establish reference elevations for extreme high water (EHW) and mean higher high water (MHHW).
4. Sites must be accessible to both surveyors and biologists.
5. Sites must be selected for suitability to test the alternative upper boundary definitions representing major habitat types and environmental conditions. The following parameters were used in defining major habitats:
    a. The sites should show differences, as reflected by differences in vegetation.
    b. The sites should represent different substrate composition.
    c. The sites should provide information on salt-water to river vegetation transition.
    d. The sites should represent extreme salinity areas.
    e. The sites should represent extreme Puget Sound wave energy regimes (as visually observed).

Secondary Criteria:

1. Sites representing natural areas subject to potential human development pressures, for which data will be most helpful at this time, should be given preference.
2. Sites for which useful historical information is available should be given preference. (Historical information in the form of tidal data, oceanographic data, and vegetation data is most useful).

The selection of sites involved several steps. First, aerial photographs were examined to locate any potential marsh areas. Second, those marshes in close proximity to known NOAA bench marks were selected. Third, a biologist and engineer traveled to each site and took notes on: (a) whether it represented a common marsh plant composition; (b) whether or not it was disturbed; (c) the feasibility of working in the marsh; (d) the accessibility of bench marks; and (e) general observations. Following these steps three initial sites were identified as meeting the above criteria: Port Madison, Harper and Nisqually Flats (Figure 1).

Three additional sites (Skagit Flats, Thorndike Bay and Gibson Marsh) were selected following notification that tidal gauges would be installed in those regions. These sites were either under development pressure or had suitable biological conditions for the purposes of this study. All sites were visited prior to the field survey to confirm that they complied with the above mentioned criteria.

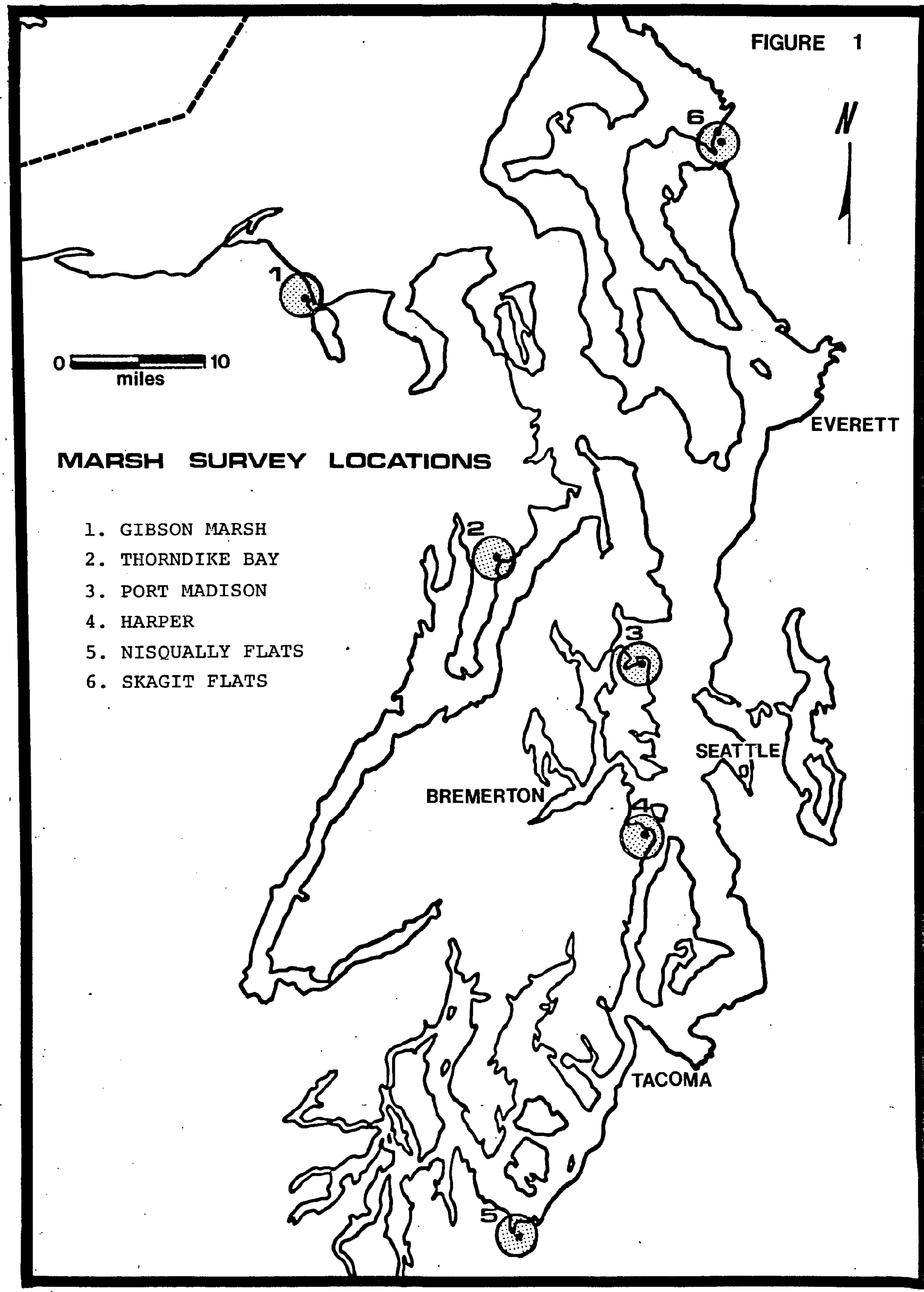


FIGURE 1
N
0
10
miles
MARSH SURVEY LOCATIONS
1. GIBSON MARSH
2. THORNDIKE BAY
3. PORT MADISON
4. HARPER
5. NISQUALLY FLATS
6. SKAGIT FLATS
1
2
3
4
5
6
EVERETT
SEATTLE
BREMERTON
TACOMA

Data Collection

PRE-SURVEY

Before sampling any of the marshes, a pre-survey was conducted to determine: 1) if three transects through the marsh would reasonably and accurately describe the floral distribution and coverage, 2) if the equipment would need modification, and 3) to identify any other unforseen problems.

Choice of quadrat size for sampling community composition was determined by comparing the results of data collected during the pre-survey of one meter square vs. one-quarter meter square quadrats. One quarter meter square quadrats were found to be adequate. This size has also been found by other investigators (Zedler, personal communication; Backman, unpublished data; Eilers, 1975; Jefferson, 1975) to be adequate in salt marshes.

A species acquisition curve for number of species versus number of replicates was drawn during the pre-test. For both quadrats and transects, two replicates was the point at which the curve leveled off. Therefore, two replicates would have been sufficient, however, three transects and six quadrats were deemed minimum for statistical purposes.

In order to test the four alternative intertidal marsh definitions some field equipment, such as coring devices, was specially designed and the proposed methods were pre-tested in the field.

After the survey methods were tested and marshes selected, the marshes were measured for ground water movement, pore water salinity, interstitial soil salinity, substrate textures, plant distributions and tidal elevations.

Presented here are the final methods for sampling procedures that were accepted by the Department of Ecology and used in the field.

GROUND WATER MOVEMENT MEASURING METHODS

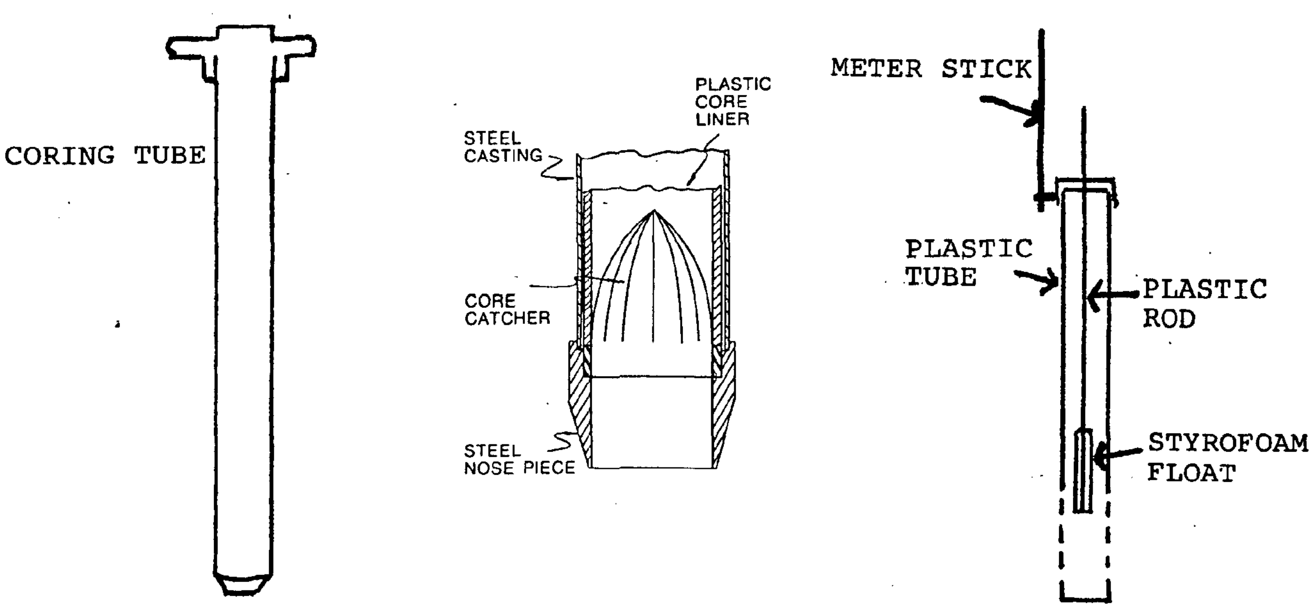
At each transect, ground water level was monitored at a bore hole at the apparent upper limit of the marsh (ULM). An additional determination(s) was made one vertical foot above (plus one foot station) and/or below (minus one foot station) the ULM point.

A one meter coring tube with a 1-7/8 inch diameter inner plastic liner (Figure 2) was driven into the sediment with a sledge hammer. The coring tube and plastic liner with its sediment sample were then removed from the ground leaving a cored hole for observaton of water level. The sediment sample was saved for further analyses; cf., sections on Interstitial Soil Salinity. A slightly narrower, 1-1/2 inch diameter, perforated plastic liner was then placed in the hole to prevent it from caving in. The perforated liner had 1/8 inch holes drilled in the lower 1.5 feet to allow free inflow and outflow of ground water such that the water level in the perforated liner would reflect the ground water level. Water level was measured from the top of a plastic rod attached to a float in the liner, against a meter stick attached to the exterior, above ground, portion of the perforated liner.

Water level in the perforated liners was allowed to come to equilibrium with the ground water by noting when the water in the cored hole no longer rose abruptly. Water level in the perforated liner was then monitored during a rising tide.

Figure 2
Core Sampler

The plastic core liner is inserted into the core sampler. The complete device is then driven into the sediments. After removal an additional core liner, which is described in the text, was placed into the cored hole.



If the minus one foot station was located in tidal waters (Thorndike, Gibson) or cobble beach (Port Madison) it was excluded. If the plus one foot station was on a bank (Nisqually) or several tens of feet into terrestrial vegetation (Harper) it was excluded. Skagit was the only site where all three stations along all three transects were sampled.

SALINITY MEASUREMENT METHODS

Pore water salinity was determined by placing the probe of a Yellow Springs Instrument Company, Model 33 salinometer into the cored holes and recording the salinity of the standing water. These determinations were made after ground water level had been recorded.

Surface water salinities of incoming tidal waters were measured along transect lines on the day of sampling while collecting other field data.

Interstitial soil salinity was determined by the methods of Jefferson (1975). Samples were taken from the upper 10cm. of the core and the bottom of the root zone when possible. The air dried soils were broken up and passed through a two millimeter sieve, then diluted 5:1 by weight with distilled water and left standing overnight. Each sample was then filtered through a 0.45 micron filter and the salinity of the filtrate determined with the YSI meter.

TIDAL ELEVATION MEASUREMENT METHODS

Elevations for points on transects and for other reference points at the sites were detemined by a professional, licensed, surveying team so that profiles could be drawn.

After a study area habitat within a marsh was located, a temporary reference benchmark (TRBM) was established in the wetland. By differential levelling (with a transit and standia rod) from a single NOAA benchmark (BM) or a temporary benchmark (TBM), an elevation was established on the TRBM. From this TRBM, the elevation of points along the transect were determined. To insure accuracy, the elevations determined were confirmed by closing the line of levels to the original benchmark. Closing within 0.1 ft. was considered acceptable for the purposes of this study.

Tidal information obtained from NOAA, Seattle, includes:

a. Elevation of the benchmark above tidal datum (MLLW) (± 0.010 ft.)
b. Elevation of MHHW (See Table 5)
c. Elevation of EHW (± 0.5 ft.)

Data available at this time provide elevations above MLLW and for MHHW to hundredths of a foot. Elevations of EHW were not as precise. The EHW water elevations were often expressed in terms of "established highest water level" or "highest tide observed." Estimated highest water levels were generally given to the nearest one-half foot.

For location and information regarding tidal gauging stations, see Appendix I.

FLORA DISTRIBUTION AND COVERAGE MEASUREMENT METHODS

At each marsh selected, three transects were established from the outer edge of emergent marsh plants up to and through the upland vegetation (Figure 3). These transects were located by first placing a 200-foot long base line parallel to the upper limit of the marsh (ULM) within the site, and selecting three points along that line using a random numbers table. Transect lines were established approximately perpendicular to the base line at each of the randomly selected points. Data was collected on plant species distribution through a two meter wide area centered on each transect extending from the upper to the lower limits of the transect excepting the upland vegetation end points.

Because there is a large variability in the percent of coverage with the seasons, only general notes on cover were taken except for the upper zone where community composition was ascertained. This upper area corresponds to the transition zone of Frenkel and Eilers (1976). Community composition of this upper zone was determined by randomly tossing a 1/4 meter square quadrat six times in the zone.

Species cover within a quadrat was then assigned ranks according to the Daubenmire method (Mueller-Dombois and Ellenberg, 1974, Table 1). This species cover data was not used to evaluate the ULM because species composition can change dramatically with seasons. However, the information is useful for understanding marsh species composition and may also be useful for future investigators. The species cover data are located in Appendix I with each marsh description.

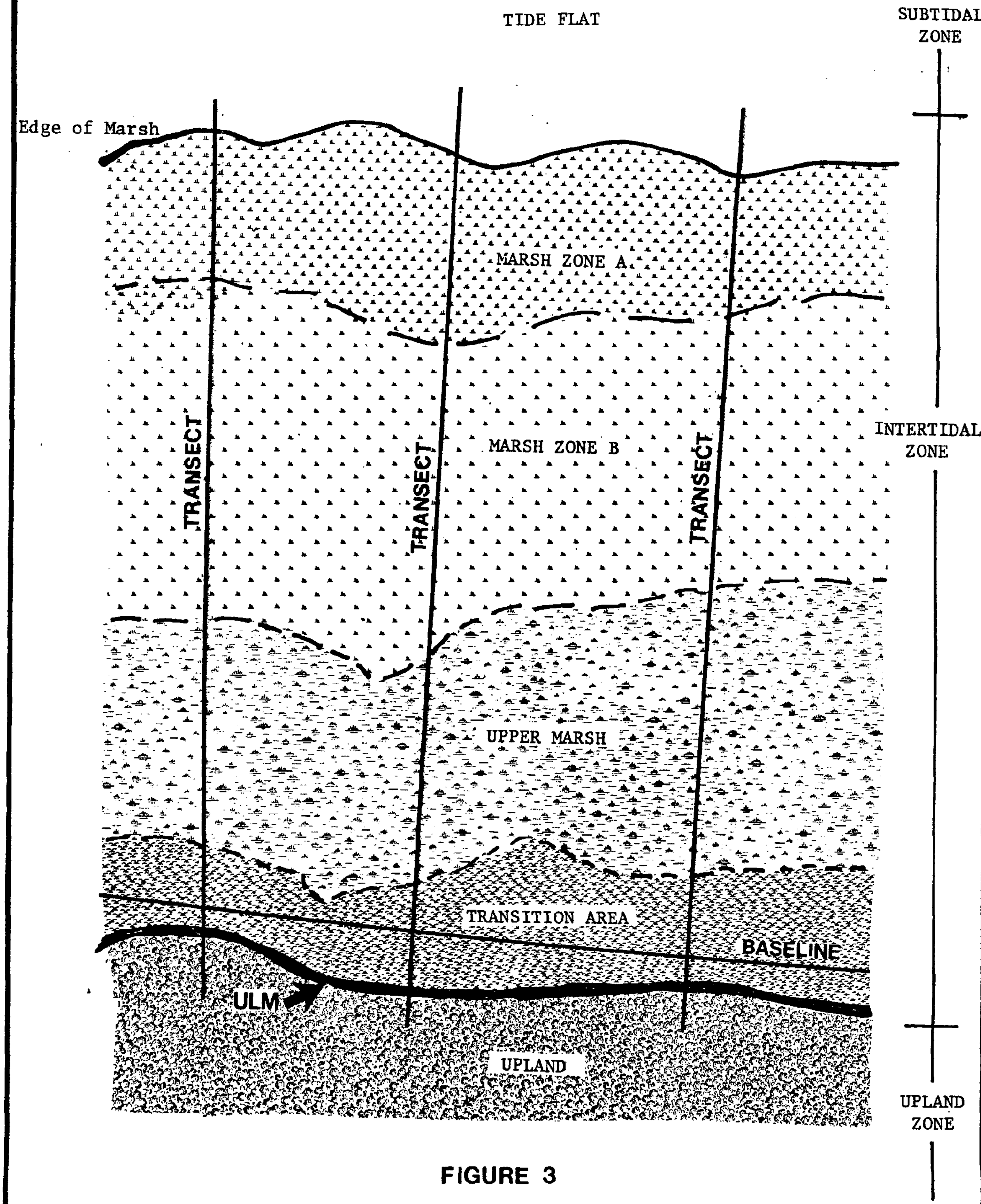


FIGURE 3

EXAMPLE OF
INTERTIDAL MARSH
TRANSECT ARRANGEMENTS

Table 1
RANKS FOR PERCENT COVER

Cover Class Rank	Range of Cover (%)	Class Midpoints(%)
6	95-100	97.5
5	75-95	85.0
4	50-75	62.5
3	25-50	37.5
2	5-25	15.0
1	0-5	2.5

The position of the ULM along the transect was a judgment decision made by the field botanist. A second botanist was always present to provide a confirming opinion. The location of the ULM was then mapped by the surveyors, under the direction of the botanist, with additional elevations along the ULM being determined at the Nisqually, Skagit, Thorndike, and Gibson sites. The ULM was positioned at the upper limits of the transition area marked by the upper extension of marsh vegetation.

SITE SELECTION

SITE SELECTION

Six sites (Figure 1) were selected to represent the major marsh habitat types and environmental conditions of intertidal Puget Sound-Strait of Juan de Fuca areas. A particular site often satisfied more than one of the sub-criteria used in Statement 5 of the primary criteria.

Table 2 lists the marshes sampled and their major characteristics.

Table 2

Characteristics of Sampled Marshes

SITE	SITE SELECTION CRITERIA										
	Salinity			Vegetation		Energy		Substrate		Disturbance	
	>25ppt	15-25ppt	0-15ppt	Fresh	Halophytes	High	Low	Sand	Loam	Disturbed	Non-Disturbed
Harper		x			x		x		x		x
Port Madison		x			x	x		x			x
Nisqually			x		x		x		x	x	
Skagit			x	x			x			x	
Thorndike		x			x	x		x	x		x
Gibson	x				x	x			x		x

Surface Water Salinity

Puget Sound and Strait of Juan de Fuca surface waters can range from a salinity of 0 ppt (parts per thousand) to 30 ppt. In order to insure that the marshes sampled reflect high, low, and intermediate values, salinity was classified as: high, 25 ppt; moderate, 15-25 ppt; and low, 0-15 ppt. The classification variations were intended to reflect the results of mixing between incoming streams, ground water incursion, and the salinity of the receiving waters.

The Gibson site is representative of an area subjected to the high salinity regime. It is inundated by relatively high salinity water from the Strait of Juan de Fuca (28-30 ppt) mixed only with incoming ground water from the uplands.

The Port Madison, Harper, and Thorndike sites are representative of intermediate salinity conditions common to areas influenced primarily by Puget Sound and Hood Canal waters. Thorndike marsh waters receive a large amount of fresh water from ground water and surface flow. They also mix readily with and are dominated by the moderate salinities of Hood Canal waters. The surface water of Hood Canal does have seasonal low salinities approaching that of freshwater after heavy rains and upland snow melts (Kollmeyer, 1965).

The Nisqually and Skagit sites are both representative of areas dominated by major rivers and fall in the low salinity range. Skagit had the lowest salinity surface waters of the sites surveyed and was considered to be a freshwater marsh subject to tidal action.

Wave Energy

The form and substrate composition of the forebeach are good indicators of the amount of storm and tidal wave energy that a beach is subject to. For example, cobble beaches with a sand berm are indicative of high energy, whereas a gently sloping high organic substrate is indicative of a low energy situation.

The Gibson, Thorndike, and Port Madison sites are portions of marsh systems that are representative of high energy situations. Thorndike is situated such that its outer berm receives the energy from wind driven waves propagated along Hood Canal. Port Madison receives wind and storm waves travelling south in Puget Sound. Gibson receives the impact from reflected ocean propagated waves travelling through the Strait of Juan de Fuca. The other sites are portions of marshes that are protected by islands or other land forms that prevent high energy waves from reaching the marsh foreshore.

Because of the protection offered by the forebeach and/or off-shore obstructions, the inland parts of the marshes are subject to lower and more uniform energy regimes regardless of the off-shore energy regime. As is evident from the plant species lists in Appendix II, the highly variable wave energy conditions on the forebeach coincide with a highly variable species distribution, and the consistantly low energy regime conditions of the transition areas coincide with a greater commonality of species. This may suggest that wave energy regime is not an important site selection criteria.

Vegetation

Upon visiting the proposed sites, all except Skagit were found to be dominated by halophytes, although there were small pockets of freshwater plants at Thorndike, and behind the dikes at Nisqually and Gibson.

The Nisqually and Skagit sites are portions of marsh systems that have been heavily disturbed by human activities. (A disturbance is defined as a physical change to the marsh such as landfill, diking, or road construction). The Nisqually and Skagit sites, represent disturbed portions due to adjacent diking.

Substrate

At the time of this initial site selection survey substrate was characterised, based on a visual examination of surface soils and sediments.

RESULTS

RESULTS

This section encompasses the results of the field surveys and laboratory analyses. The results of data collection are summarized in a form that aids in the final analysis of the alternatives in the Discussion Section. Complete descriptions of each marsh (including all raw data) are found in Appendix I.

Ground Water Movement

The vertical movement of ground water did not always show consistant trends at the same marsh between replicates (Table 3). For example, at the Yukon ULM -1ft station, the total change of water level was +5.7cm for Transect A, -1.2 cm for Transect B, and +3.9cm for Transect C. At Gibson both the transition (ULM) and transition plus one foot (ULM +1') stations were flooded by the incoming tide. At Port Madison the ULM station at Transect A decreased by -1.3cm and increased by +1.6cm at Transect B. The temperature and salinity of the waters within the core holes were very much different (Table 3) at transects (13.7°C, 0.5 ppt for A; 8°C, 24 ppt for B; 12°C, 0.5 ppt for C) at Port Madison.

The coring equipment continually required repair because of the severe beating it took during insertion into the earth. While the core hole liner prevented the sides from caving in, it may have impeded water flow. This could occur when large particles such as gravel or organic matter lodged against the holes in the liner, thereby blocking water exchange. The float also required approximately 5 cm of water to enter the tube before it would show signs of movement. However, a meter stick was placed in the hole to measure water movement when no float movement was noted. Capillary water movement was avoided due to the large 1-1/2 inch bore diameter of the coring tube.

Interstitial Soil Salinity

Many of the results obtained from interstitial soil salinity analyses indicated no measurable salinity (Table 4). The highest value, 3.5 ppt, was measured at Nisqually. These values contrast with those of Jefferson (1975), who found higher values (3-5 ppt), during the same seasonal period in Oregon estuaries. In December 1973, Jefferson observed 0 ppt at one site. In this study, the data from Thorndike and Gibson sites showed no measurable soil salinities. They also showed low values of pore water salinities (Table 3).

TABLE 3

GROUNDWATER DATA*

SITE	TRANSECT A				TRANSECT B				TRANSECT C			
	Total time elapsed (min.)	Total change in cm.	Temp. °C.	Salinity ppt	Total time elapsed (min.)	Total change in cm.	Temp. °C.	Salinity ppt	Total time elapsed (min.)	Total change in cm.	Temp. °C.	Salinity ppt
HARPER												
Transition	82	0	--	--	104	0	--	--	103	0	--	--
Transition -1'	82	+5.7	12.2	8.1	104	-1.2	--	--	103	+3.9	12.0	7.0
PORT MADISON:												
Transition	65	-1.3	13.7	0.5	65	+1.6	8.0	24.0	65	+0.3	12.0	0.5
Transition +1'	65	0	--	--	65	0	--	--	65	0	--	--
NISQUALLY:												
Transition	177	0	--	--	137	0	--	--	133	+3.7	18.1	2.5
Transition -1'	177	+4	17.0	1.5	137	+35.91	16.0	8.5	133	+1.3	18.5	11.5
SKAGIT												
Transition	186	+58.8	15.3	1.0	62	flooded	15.3	1.0	75	flooded	15.3	1.0
Transition +1'	186	+18.6	15.0	0.5	62	+20.0	15.3	0.5	75	+80.0	15.0	0.5
Transition -1'	186	flooded	15.3	1.0	62	flooded	15.3	1.0	75	flooded	15.3	1.0
THORNDIKE												
Transition	60	0	10.5	0.0	60	-2.1	11.5	0.0	60	+1.5	17.5	0.0
Transition +1'	60	+1.5	10.5	0.0	60	0	12.5	0.0	60	0	--	--
GIBSON												
Transition	70	flooded	10.0	2.8	70	flooded	10.0	2.0	70	flooded	10.0	2.0
Transition +1'	70	flooded	10.0	2.5	70	flooded	10.0	2.8	70	flooded	10.0	2.5

*Summerized from data in appendix

TABLE 4 INTERSTITIAL SOIL SALINITIES

Salinities as parts per thousand for 10 cm depth and bottom of root zone where feasable. Core length and substrate texture also noted.

SITE	TRANSECT	Salinity, ppt *		Core Length cm.	Sediment Texture (based on field observations)		Notes
		Top 10 cm.	Bottom of Root Zone		Top	Bottom	
HARPER							
Transect	A, T	0.00	----	22	Sand/Organic	Sand	Root end at 8 cm.
	A, T -1	2.50	----	24	" "	"	" " " 15 "
	B, T	0.25	0.0	54	" "	"	" " " 44 "
	B, T -1	2.00	2.0	16	" "	"	" " " 7 "
	C, T	0.00	0.0	44	" "	"	" " " 34 "
	C, T -1	0.75	----	45	" "	"	" " " Bottom
PORT MADISON							
Transect	A, T	0.50	----	20	Peat/Gravel	Gravel	
	A, T +1	0.00	----	38	" "	"	
	B, T	1.00	----	26	Peat	Sand	
	B, T +1	0.10	----	15	Loam	Gravel	
	C, T	0.50	1.0	43	Peat	"	
	C, T +1	0.00	0.0	37	"	Sand	
NISQUALLY							
Transect	A, T	0.00	0.0	74	Mud/Sand	Mud/Sand	Root end at 45 cm.
	A, T -1	0.00	0.5	72	" "	" "	" " " Bottom
	B, T	0.00	0.5	60	" "	" "	" " " "
	B, T -1	0.00	1.5	60	" "	" "	" " " "
	C, T	0.00	0.5	67	" "	" "	" " " "
	C, T -1	0.50	3.5	45	" "	Sand	" " " "

* ppt = parts per thousand

TABLE 4 CONT.

SITE	TRANSECT	Salinity, ppt * Top 10 cm.	Bottom of Root Zone	Core Length cm.	Sediment Texture (based on field observ.) Top	Bottom	Notes
SKAGIT							
	Transect A, T -1	0.00	0.0	24	Mud	Sand	Roots to Bottom
	A, T	0.00	0.0	43	"	Mud	" " "
	A, T +1	0.00	0.0	40	"	"	" " "
	B, T -1	0.00	0.0	63	"	"	" " "
	B, T	0.00	0.0	53	"	Sand	" " "
	B, T +1	0.00	0.0	48	"	"	" " "
	C, T -1	0.00	0.0	53	Peat/Sand	Mud	" " "
	C, T	0.00	0.0	44	Sand	Sand	" " "
	C, T +1	0.00	0.0	53	Peat/Sand	Peat/Sand	" " "
THORNDIKE							
	Transect A, T	0.00	0.0	22	Loam	Loam	" " "
	A, T +1	0.00	0.0	17	"	"	" " "
	B, T	0.00	0.0	24	"	"	" " "
	B, T +1	0.00	0.0	9	"	"	" " "
	C, T	0.00	0.0	5	"	"	" " "
GIBSON							
	Transect A, T	0.00	0.0	13	Loam	Loam	" " "
	A, T +1	0.00	0.0	19	"	"	" " "
	B, T	0.00	0.0	28	"	"	" " "
	B, T +1	0.00	0.0	27	"	"	" " "
	C, T	0.00	0.0	5	"	"	" " "
	C, T +1	0.00	0.0	5	"	"	" " "

* ppt = parts per thousand

It should be noted that the core lengths aré not always equal and often only 20-50 cm long rather than the expected 1 meter. Compaction of the soils in the liners accounts for most of the discrepancy. However, whenever a large wood chip, rock, or gravel particle was encountered there was a tendency for the core to punch a hole into the sediment rather than core a hole. If this occurred, a core adjacent to the previous one was taken. In the event of a gravel bottom, the adjacent core hole would compact and punch in the same manner and only a limited sample could be obtained for laboratory analysis.

Tidal Elevations

Where tidal information was available the surveyors used the closest available benchmark (for location and description of NOAA benchmark data see Appendix I). At Nisqually the surveyors used a Temporary Benchmark installed by U.S. Fish and Wildlife staff which was referenced to NOAA tidal data at Dupont (Appendix I). At the Port Madison, Harper, and Gibson sites the surveyors were able to utilize NOAA benchmarks directly. Tidal elevation data is available only for the benchmarks used at Nisqually, Port Madison and Harper. The new tidal elevation data for the Gibson benchmark has not been processed by NOAA at this time.

It is anticipated that tidal gauges will be installed in the vicinity of the Skagit and Thorndike sites, and that tidal elevation data will be collected and analysed. This process is expected to take approximately six to nine months from January 31, 1977.

When the additional tidal information for Gibson, Skagit and Thorndike becomes available, Table 5 may be completed.

Table 5

ELEVATIONS OF UPPER LIMIT

OF MARSHES (ULM) IN FEET ABOVE MHHW*

SITE	MHHW	N	$\overline{X}$ (ULM)	S.E. (ULM)	Δ ULM - MHHW $\pm$ S.E. from MHHW
Harper	11.40	3	12.12	0.28	0.72 $\pm$ 0.28
Port Madison	11.40	3	11.93	0.21	0.53 $\pm$ 0.21
Nisqually	13.40	14	14.45	0.80	1.05 $\pm$ 0.80
Skagit	**	16	**	0.78 [1]	**
Thorndike	**	17	**	0.89	**
Gibson	**	9	**	0.58	**

* MHHW is given as height in feet above MLLW
N = Number of ULM determinations made
$\overline{X}$ = Mean height of ULM above MLLW
S.E. = Standard error of determining ULM based on vegetative criteria.
$\Delta \overline{X}$ = ULM - MHHW plus or minus S.E. Values for N and S.E. are given only for Skagit, Thorndike and Gibson pending inclusion of tidal data (See text for details).
** To be completed when data are available.
[1] Actual values in Appendix I

Flora Distribution and Community Composition

Along the three transects at each marsh, data on species presence and absence were obtained. Many of these plants are predominantly located in the lower marsh or upland areas. Those species which have their upper or lower limit located in the transition zone are listed in Tables 6 and 7. For the complete species list refer to Appendix II and for the distributions, see Appendix I. Nomenclature follows that of Hitchcock and Cronquist (1974).

The species list (Tables 6 & 7) for freshwater and saltwater marshes is primarily for the autumn season in the Puget Sound-Strait of Juan de Fuca region of Washington State. However, because the plants were at the end of their growing season the species list should also apply to the summer- autumn season. Also, many of the species can be identified from vegetative characteristics in the winter. Often those species distinguishable in the autumn are even easier to identify in the spring. One divergence from the autumn data would be seasonal changes in species abundance and the occurrence of the annuals. In this study, annuals, when located, could be identified by vegetative characters or dead flowers. Freshwater marsh plants are included in the list because the term "tidally influenced, aquatic lands" includes many freshwater marshes that are subject to tidal action. Species composition for the upper marsh zone are provided with each marsh description (Appendix I). The data is not presented in this section because it provides only limited, site-specific information to test this alternative. However, following the spring and summer studies by EPA consultants, the community composition information may be combined into a more complete yearly picture.

The variability of a transition line is presented in Table 5.

TABLE 6

DIAGRAMMATIC DEPICTION OF THE DISTRIBUTION OF PLANTS FOUND IN THE TRANSITION ZONE OF SALT MARSHES

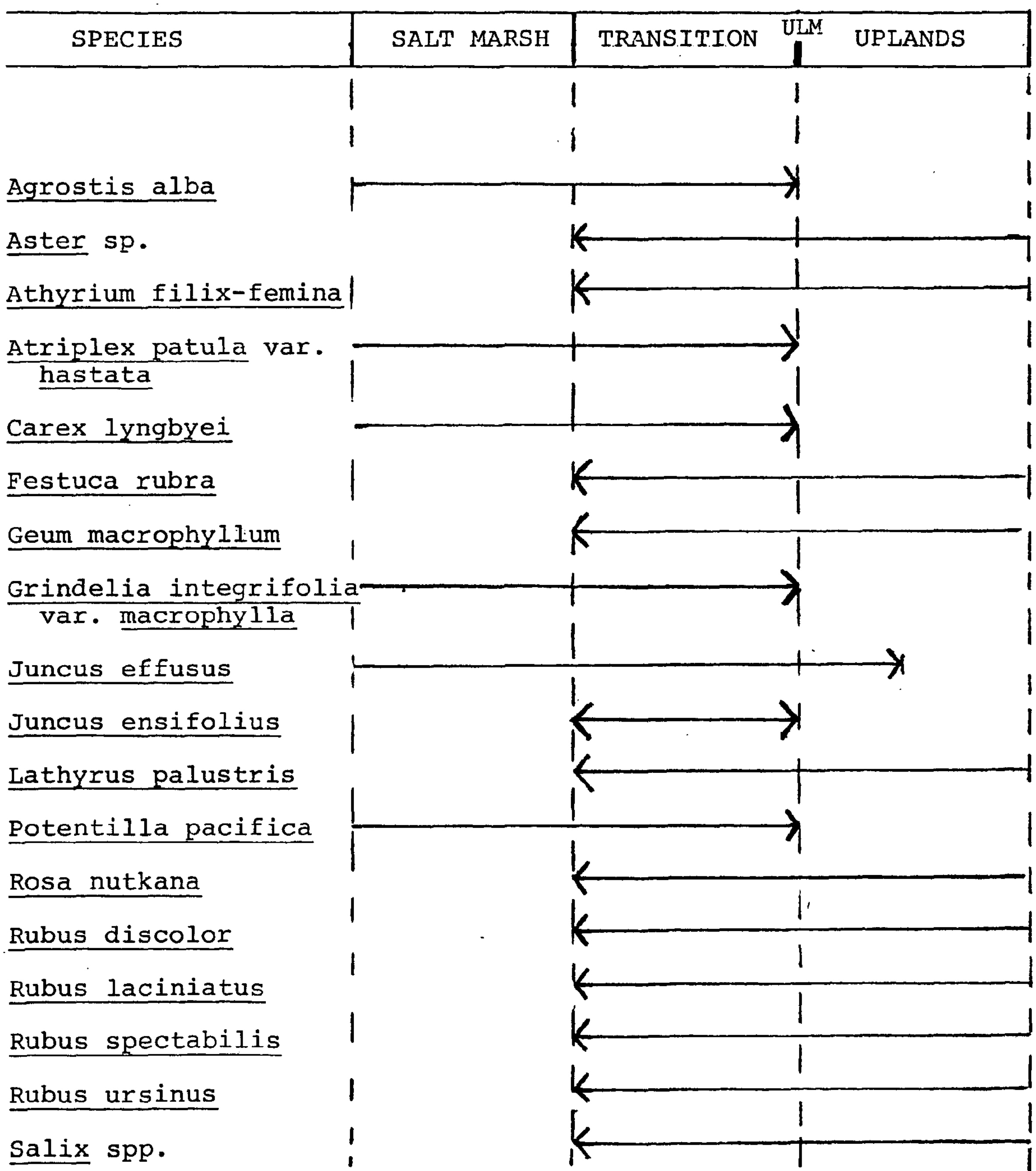
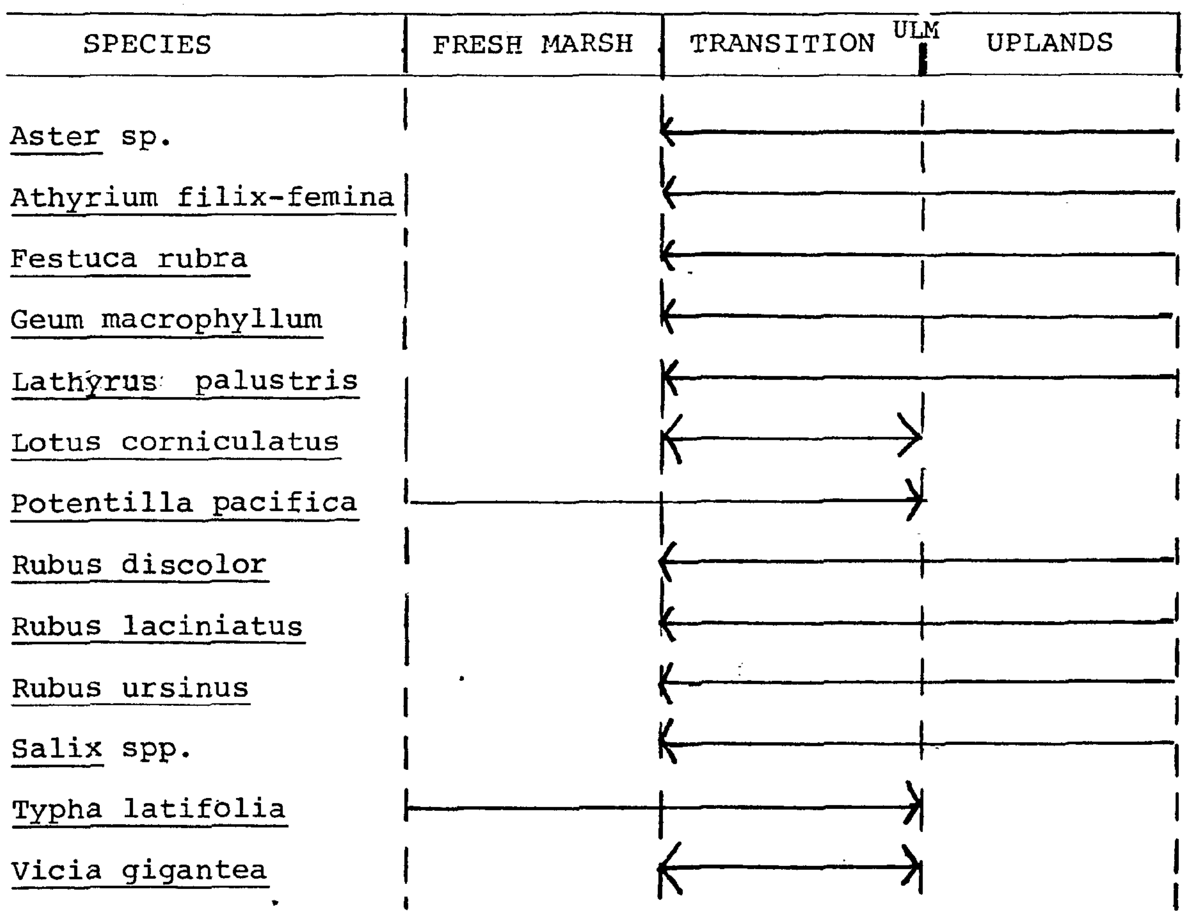


TABLE 7

DIAGRAMMATIC DEPICTION OF
DISTRIBUTION OF PLANTS FOUND IN
THE TRANSITION ZONE OF THE UPPER PART OF
FRESHWATER MARSHES *



* For Data from Skagit, see Appendix I

DISCUSSION

DISCUSSION

This section analyses the applicability of the four alternatives tested to delineate the upland boundary of Washington State marine marsh lands. A suggested rewording of two alternatives is then presented followed by a new recommended definition. The analysis of tidal height and its relationship to vegetative criteria is incomplete and will remain so, pending the incorporation of tide gauge information from additional sites to be studied.

Analysis of Tested Alternatives as Indicators of Intertidal Marshes Upper Boundary

GROUND WATER MOVEMENT

The validity of defining the upland boundary of marsh lands as: "areas where ground water rises and falls due to tidal action," was not supported by this study. The results of ground water vertical movement measurements were not consistant and were subject to numerous errors. The data suggest that a complete understanding of the relationship between ground water movement and the ULM is too complex to be evaluated by the methods employed.

The degree of rise in ground water due to tidal action is a function of tidal height at the time of sampling, soil permeability, and any hydrologic freshwater head. Chapman (1976) mentioned that peat soils will show little ground water effects, whereas high porosity soils, such as sand, have a good response. In the field, it was found that a peat soil was overlaying mixed composition sediments 19% of the time.

Thus, use of this method to delineate the upper boundary could be seriously challenged. The method of obtaining the information would also need further refinement. The influence of seasonal and site-specific factors on ground water vertical tidal movement serves to further decrease the value of this alternative as a useful means of determining the ULM.

INTERSTITIAL SOIL SALINITY

We also examined the validity of defining the upland boundary of marsh as: "areas which have an interstitial soil salinity greater than or equal to two parts per thousand." As with the ground water movement, interstitial soil salinity data did not exhibit any observable trends that would clearly delineate the upland boundary for marsh lands. The values were, for the most part, lower than the findings of Jefferson (1975) for Oregon's marshes.

Comparing the results for interstitial soil salinity with pore water salinity (Table 4 with Table 5), the latter was higher, except for Thorndike which had 0 ppt for the pore water. Thorndike, as previously mentioned, has a strong underground flow of freshwater from the surrounding uplands.

In situ pore water salinity was not always measurable (Table 4). At Skagit, the pore water salinity did decrease from 1 ppt to 0.5 ppt salinity between the transition station and the transition plus one foot station (Table 4). At Thorndike and Gibson (Table 4) no distinction between the transition station and the transition plus one foot level was found.

Based on the data collected, neither interstitial soil salinity or in *in situ* pore water salinity measurement provided the level of precision necessary to delineate the upland boundary of aquatic lands. Therefore, this alternative would also be subject to serious challenge.

TIDAL ELEVATION

The validity of defining the upland boundary of marsh lands as "Areas below an elevation of one foot above Extreme High Water" has been evaluated. A definitive evaluation of the use of this alternative will depend on the incorporation of tidal data for Gibson, Thorndike, and Skagit. However, a few observations can be made at this time.

Extreme high water (EHW) information obtainable from NOAA is often in error by as much as 1/2 foot according to notes in NOAA data. Its precision is also dependent upon an observer being at the site when an extreme high tide occurs. At sites where this value has been recorded (Nisqually, Harper, and Port Madison), the extreme high water level extends several feet into the terrestrial vegetation (Appendix I).

From data available at this time, the upper marsh boundary appears to be above MHHW and below EHW. The locations of MHHW relative to the upper limit of the marsh for Nisqually, Port Madison, and Harper are presented in Table 5. For the three marshes noted, the ULM is located above MHHW and below EHW.

In Chesapeake Bay the upper limit boundary is defined by Boon et al (1976) to be 0.95 feet above MHW (= MHHW on the West Coast) for saline marshes and 0.59 feet above MHW for freshwater marshes. Their determination of MHW was based on data from 13 sites and part of a precise datum network established by NOAA.

Along the diked areas of the southwest Netherlands, Beeftink (1975) suggested that "euryhaline halophytes seem to be confined to fixed levels with respect to tides." He further adds that the species descend from the supralittoral zone above "Mean High Water springs" (equivalent to MHHW). However the precise value for the fixed level with respect to tidal level was not provided.

The use of MHHW as a tidal base plane for defining marsh boundaries appears to have more merits than the use of EHW. The MHHW is readily and accurately determined from existing NOAA data or is easily measured by placement of a tidal gauge. In a study recently completed in Oregon, Frenkel and Eilers (1976) noted that MHHW has a greater accord with floristic data. Vegetation may be expected to have a better correlation with MHHW as a base plane than EHW because plant species would be more sensitive to regular inundation than to infrequent flood tides. Because MHHW provides the best accord with floristic data it will be the tidal plane considered as a reference plane for the following discussion.

There are two principle sources of variance in the use of elevation information. First, there are inherent errors in the tidal datum computations by NOAA, associated with the duration of observations at a tidal gauge. Secondly, there are errors associated with variation in the upper boundary as determined by vegetation. The variance due to both types are additive. Swanson (1974) gives standard deviations for the first inherent error above MHHW for Seattle area tidal data as follows:

Period of Measurement	Standard Deviation
1 month	0.138 feet
3 months	0.107 feet
6 months	0.073 feet
12 months	0.056 feet

The variance associated with the mean difference, ΔY= ULM - MHHW, is therefore:

$S_{\Delta Y} = S_1^2 + S_2^2 / n_2$ (adopted from Boon, et al. (1976) where S_2 = standard deviation of upper marsh boundary (Table 5) and n_2 = number of measurements. Confidence limits at the .05% level utilizing a student's t statistic will be evaluated when data for all six sites are available.

The effect of an inaccurate determination of the vertical placement of the ULM may be seen in the work of Boon, et al. (1976) who conducted an extensive evaluation of this problem on the Atlantic Coast and produced the following table:

TABLE 8

Horizontal Displacements of the ULM Boundary in Feet for Typical Combinations of Vertical Error and Ground Slope*

Vertical	Slope				
Error($S_{\Delta y}$ ft.)	2%	4%	6%	8%	10%
± 0.05	± 2.5	± 1.2	± 0.8	± 0.6	± 0.5
± 0.10	± 5.0	± 2.5	± 1.7	± 1.2	± 1.0
± 0.15	± 7.5	± 3.8	± 2.5	± 1.9	± 1.5
± 0.20	±10.0	± 5.0	± 3.3	± 2.5	± 2.0
± 0.25	±12.5	± 6.2	± 4.2	± 3.1	± 2.5

* Adopted from Boon et al (1976)

Thus, a moderate vertical error in a marsh with a flat slope such as Harper (2%), could cause a major portion of the marsh to be excluded, or a significant upland area to be included within a wetlands boundary line.

It is evident, then, that the relative usefulness of a boundary line, based on tidal elevation is dependent on: 1) the precision of the determination of MHHW in the vicinity of the site under consideration, 2) the accuracy of the original floristic studies relating MHHW to the upper marsh lands boundary, and 3) the interaction of any error in the determination of vertical demension with the slope of the marsh.

The data collected from Nisqually, Harper, and Port Madison indicate the marsh upper boundary is located between 0.24 feet and 1.86 feet above MHHW. Frenkel and Eilers (1976) found a mean value for the upper marsh limit to be 1.05 feet above MHHW. The mean of the range for the three marshes of this study is 1.05 feet above MHHW, remarkably similar to the Oregon marshes.

FLORAL DISTRIBUTION

The last and most important alternative evaluated was defining the upland boundary of aquatic lands as: "Areas denoted by the presence of one or more of the following plant species..." (see Introduction for species list).

From the species and their distributions found during the study it became apparent that a revision of the original list would be necessary. The original list (See Introduction) was primarily limited to the area of aquatic lands, but not the upland boundary. It was also observed that there were certain marsh species and upland species that converged at the ecotone between the marsh and upland at the ULM.

The marsh areas studied can each be roughly divided into three elevation zones: intertidal marsh, transition area, and upland area. The transition area of salt marshes is characterized by the disappearance of intertidal halophyte marsh species and the beginning of upland species (Table 6). The ULM was considered to be the point along a transect where the last occurring marsh plant(s) ended. The width of the ULM is indicated by the variance of the ULM.

With two exceptions (*Typha latifolia* and *Carex lyngbyei*), most of the species on the original species list under consideration occurred in the lower zones of the marsh and were not found at the ULM.

The transition area flora is comprised of several marshland and upland species (Tables 6 and 7). Therefore, no single species can unequivocally define the upper limit of a marsh. Although the marshes studied are separated geographically and have a variety of physical differences, the transition zones have common plants and community compositions.

The upland plants are much more diverse than marsh plants. However, because it may be useful to delineate the ULM from the landward side, upland species should also be considered. They are much more influenced by substrate, drainage, physical disturbance and competition with weedy species. As such, a list based on upland species is longer and subject to more time dependent changes than a species list based primarily on marsh plants.

Although these species can exhibit seasonal changes in abundance, most will be present in some recognizable form throughout the year. Some species may not be evident in all seasons. Therefore, one should not exclude an area if a particular species cannot be found. The whole list should be utilized.

The transition area or ecotone as described for Oregon's estuaries by Eilers (1975) and Jefferson (1976) is analogous to Puget Sound's transition area. Eilers cites a Potentilla-Oenanthe community dominating most of the ecotone, and a Picea-Salix community at the upper marsh boundary. This study also found an ecotone, but with different plants present.

For a salt marsh-upland transition common species are: Agrostis alba, Aster sp, Carex lyngbyei, Juncus spp and Grindelia integrifolia, Rosa nutkana, Rubus spp and Salix spp. Carex lyngbyei and Grindelia integrifolia often end prior to the ULM. The trailing species such as blackberries Rubus spp) often were rooted in the upland but vined out over the grasses. Potentilla pacifica, a common Oregon transition plant was rarely found in this study. This species is primarily a spring and early summer dominate (Jefferson, 1976) which may explain its low abundance in the fall.

Even though the transition area is 100% covered, logs may be present. Often upland grass or tree seedlings grow on top of the decomposing logs. This allows common upland species like Festuca rubra and Rubus spp to be located further seaward than if logs were absent.

Frenkel and Eilers (1976) suggest using Potentilla pacifica, Aster subspicatus, and Oenanthe sarmentosa for a coastal salt marsh, and Impatiens noli-tangere, Carex obnupta, and Athyrium filix-femina for a freshwater marsh. Their list is limited in usefulness to the summer season and can only be approached from the marsh side of the ULM. It may also be useful to approach the marsh from the uplands. Also, there are often different plants common to the Puget Sound marshes.

Sundquist and Lighthard (1973) conducted a summer-fall plant survey of Padden Creek marsh near South Bellingham. Their report did not provide us with additional information to evaluate the ULM because they worked along a railroad track which was heavily disturbed. Also, they did not record tidal heights.

Basically, there is a larger species pool for potential colonization by upland plants than marsh plants. However, the physical regime of marshes is often too extreme for upland plants. If, for example, one or the other zone of plants were absent there would be a higher probability of marsh plants being able to move upward rather than of upland plants being able to invade the marsh. Thus, absolute numbers of species is not as critical as physiological tolerances. The results of such strong competition in the upland generally excludes marsh plants. The rather definitive line is thought to represent the transition area where upland plants are physiologically excluded from growing in the marsh (Pielou and Routledge, 1976). Often it is observed that trees or vines will spread their canopies or trailings out on to a marsh, but are not rooted there. This may or may not shade out marsh plants thus leaving a bare area at the transition zone. Such was observed at Transect C at Nisqually (Appendix I).

Based on Tables 6 and 7, which list the upland and marsh species and depict their occurrence in the three zones, the following list of species common to saline and freshwater transition ULM have been extracted: (Agropyron repens was excluded because it is a weedy species that can be found in the uplands).

MARSH SPECIES WITH UPPER LIMITS OCCURRING AT THE ULM

A Agrostis alba
B Atriplex patula var. hastata
C Carex lyngbyei
D Grindelia integrifolia var. macrophylla
E Juncus ensifolius
F Potentilla pacifica
G Typha latifolia
H Vicia gigantea

UPLAND SPECIES WITH LOWER LIMITS OCCURRING IN THE TRANSITION AREA

A Aster sp.
B Athyrium filix-femina
C Festuca rubra
D Geum macrophyllum
E Lathyrus palustris
F Lotus corniculatus
G Rosa nutkana
H Rubus discolor
I Rubus Laciniatus
J Rubus ursinus
K Salix spp.

SUMMARY

The use of interstitial soil salinity or ground water movement does not appear to offer the precision necessary to base a definition of an aquatic lands boundary. Tidal data and floristic data do appear to offer a viable basis for a definition describing aquatic land upland boundaries.

However, the use of only tidal datum or only flora to determine the ULM may not always yield the desired results. For example, if for some reason a disturbance occurred in a transition area which essentially devegetated the site, a species list would be of little value. Furthermore, the relationship between the ULM and tidal elevations is not precise. When additional data are available on the relationship between the ULM and MHHW, the variability may decrease, thereby increasing the precision of the relationship.

Large geographic areas could be tentatively designated as aquatic lands by planners and decision-makers based on tidal elevations, pending a field check of species distributions and tidal height. When a floristic survey has been completed, then a final, more precise line may be drawn for the region in question.

Recommended Alternatives

Based on information available at this time, the following alternative guidelines to the term "strongly influenced" are suggested:

Alternative One: Areas delineated by the upper boundary of the following plant species:

A Agrostis alba
B Atriplex patula var. hastata
C Carex lyngbyei
D Grindelia integrifolia var. macrophylla
E Juncus ensifolius
F Potentilla pacifica
G Typha latifolia
H Vicia gigantea

and/or areas delineated by the lower boundary of the following species:

A Aster sp.
B Festuca rubra
C Geum macrophyllum
D Lathyrus palustris
E Lotus corniculatus
F Rosa nutkana
G Rubus discolor
H Rubus laciniatus
I Rubus ursinus

Alternative Two: Areas below an elevation of X* feet above Mean Higher High Water

Since both alternatives above have value, it appears appropriate to combine their elements to form a revised definition. Currently this definition applies only to the Puget Sound-Strait of Juan de Fuca regions of Washington.

" Any area under or intermittently covered by waters which rise and fall due to tidal action up to the line of Mean Higher High Water plus X* feet, and an area contiguous to and above that line until all the following species cease to appear."

A Agrostis alba
B Atriplex patula
C Carex Lyngbyei
D Grindelia integrifolia var. macrophylla
E Juncus ensifolius
F Potentilla pacifica
G Typha latifolia **
H Vicia gigantea

* This value cannot be determined until additional tidal data is available.
** This species is indicative of a fresh water marsh and, therefore, may be found further inland than the halophyte species when the fresh water is subject to tidal action.

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Appendices

APPENDIX I

MARSH DESCRIPTIONS

Each Site is described as follows:

1. General description of marsh
2. Vicinity Map (from USGS and CGS quadrangle maps)
3. Aerial Photograph
4. Vegetation Zone map
5. Vegetation description of transects
6. Transect profile
7. NOAA (or other) benchmark description
8. Groundwater movement data
9. Community Composition data

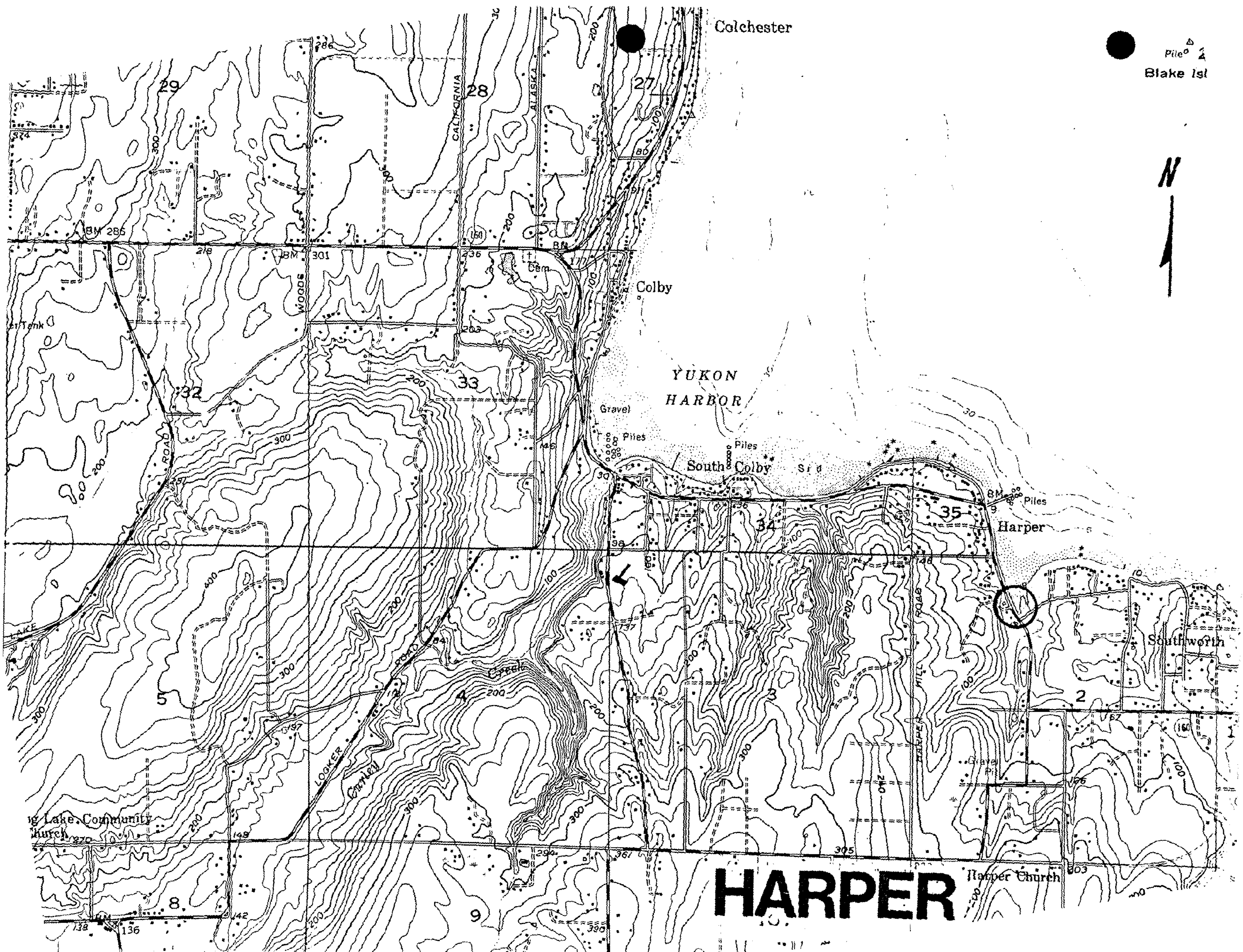
HARPER

HARPER MARSH

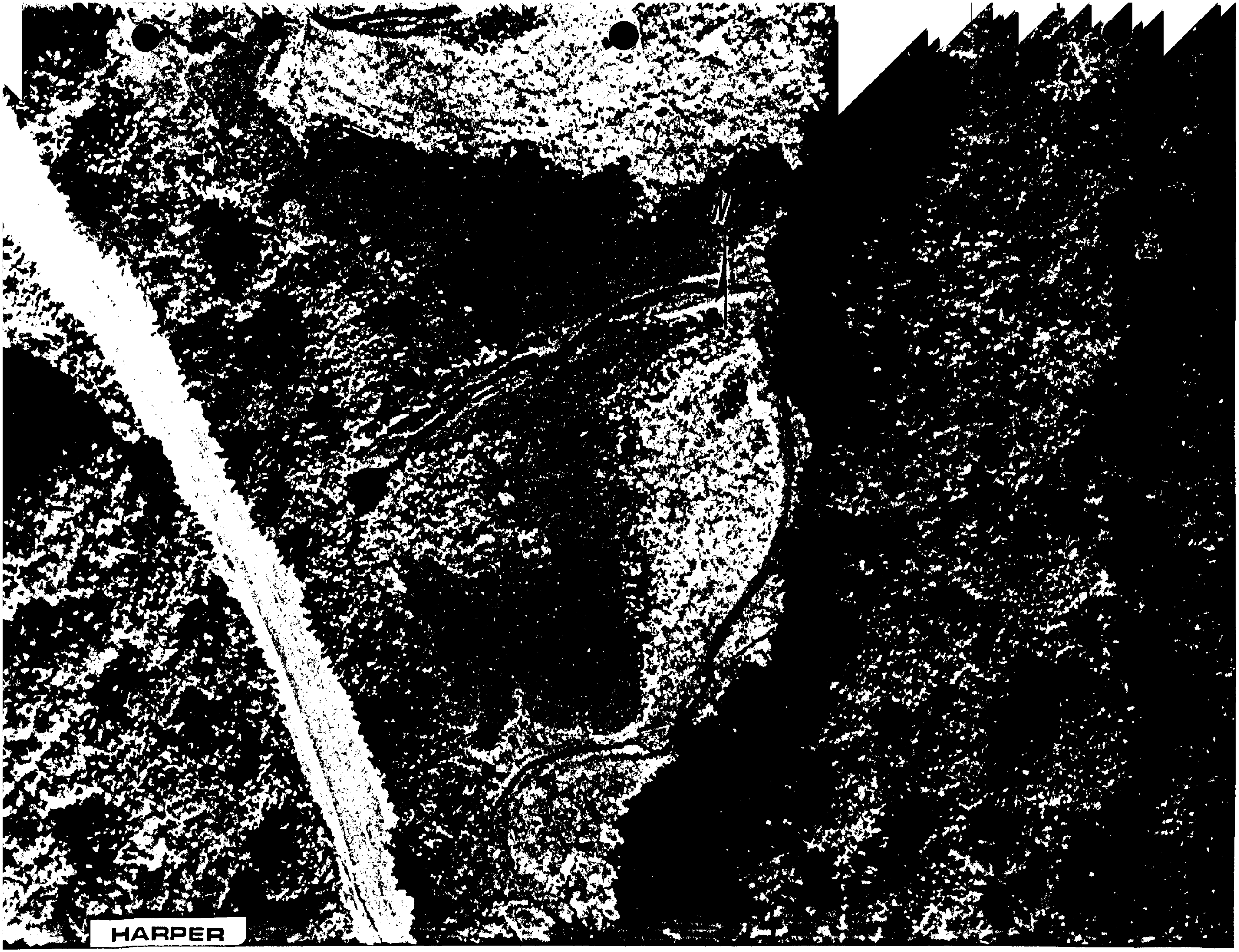
This wedge shaped marsh opens to Rich Passage between south Bainbridge Island and the Kitsap Penninsula. The marsh has two freshwater creeks entering it, one from the south and another from the east. A road and its associated bank are located 0 to 100 feet from the east side of the marsh. This road prevents a freshwater marsh from direct contact with the salt marsh by a culvert that drains into a channel.

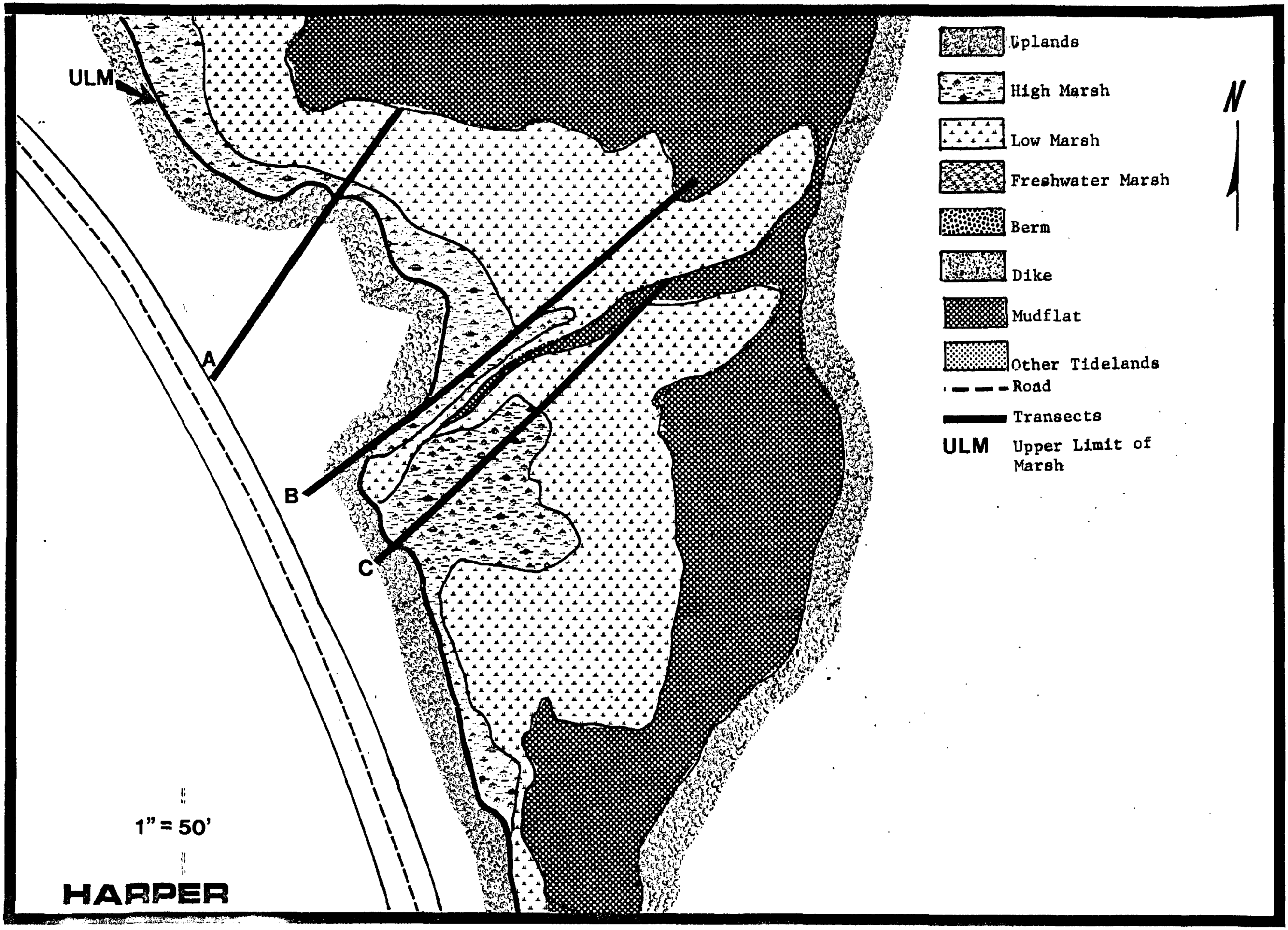
The north part of the lagoon is crossed by a highway which has a boat ramp and dike (not shown on figure). North of the road, behind the dike is a mixture of halophytes, fresh water and domestic plants. This outer area is used extensively for water oriented recreation.

The marsh is considered a major waterfowl area by the Washington State Department of Natural Resources in its Washington Marine Atlas (WSDNR, 1974) and has an eelgrass bed just outside in the harbor. With the outer marsh used extensively for recreation and the inner marsh filling in, the future of the area as a waterfowl habitat and a high marsh productivity area is questionable.



Colchester
Blake Isl
N
Colby
YUKON
HARBOR
South Colby
Harper
Southworth
Harper Church
HARPER
CALIFORNIA
ALASKA
WOODS
ROAD
LOCKER ROAD
HARPER HILL ROAD
Curley Creek
Cem
Gravel
Piles


HARPER
N



ULM
A
B
C
Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM Upper Limit of Marsh
N
1" = 50'
HARPER

SITE: Harper

TRANSECT NUMBER: A

DATE OF SAMPLING: Sept. 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
9.51 feet	0	Mud-Salicornia virginica-Distichlis spicata interface	
	10	Atriplex patula var. hastata	B
	30	Triglochin maritimum	B
11.40	32	Juncus gerardii	B
		Distichlis spicata	E
		MHHW	
	42	Salicornia virginica	E
	43	Hordeum brachyantherum	B
	46	Agrostis alba var. palustris	B
	49	Festuca rubra	B
12.34	56	End of Marsh (ULM)	
		Atriplex patula var. hastata	E
		Triglochin maritimum	E
		Juncus gerardii	E
		Hordeum brachyantherum	E
		Festuca rubra	E
		Agrostis alba var. palustris	E
		Cytisus scoparius	B
	57	Equisetum telmateia	B
	92	Polystichum munitum	B
		Osmaronia cerasiformis	
15.00	126.5	EHW	
16.00	128.6	EHW +1	
		Pseudotsuga menziesii	B

* B= Begins, E=Ends

SITE: Harper

TRANSECT NUMBER: B

DATE OF SAMPLING: Sept. 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
9.56	0	Mud-*Salicornia virginica* -*Distichlis spicata* interface	
	31	*Atriplex patula* var *hastata*	B
11.40	73.8	*Juncus gerardii*	B
		MHHW	
	79	*Agrostis alba* var. *palustris*	B
	82	*Hordeum brachyantherum*	B
		Festuca rubra	B
	94	*Plantago maritima*	B
		Triglochin maritimum	B
	98	*Salicornia virginica*	E
12.22	101.6	End of Marsh (ULM)	
		Distichlis spicata	E
		Atriplex patula var. *hastata*	E
		Juncus gerardii	E
		Hordeum brachyantherum	E
		Festuca rubra	E
		Plantago maritima	E
		Triglochin maritimum	E
		Agrostis alba var. *palustris*	E
		Cytisus scoparius	B
		Rubus discolor	B
15.00	184.6	*Acer macrophyllum*	B
		Pseudotsuga menziesii	B
		EHW	
16.00	185.6	EHW +1	

* B = Begins, E = Ends

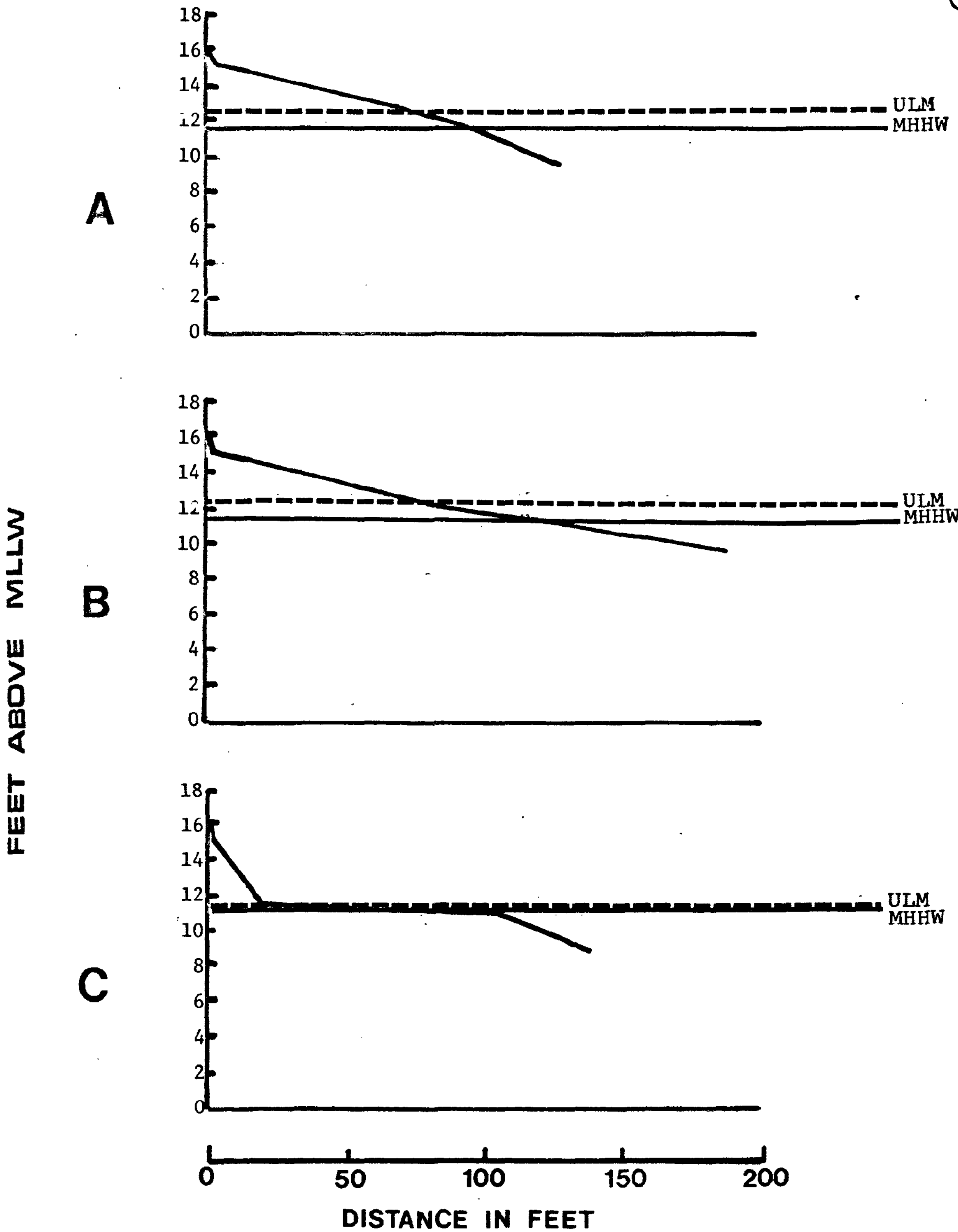
SITE: Harper

TRANSECT NUMBER: C

DATE OF SAMPLING: Sept. 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
9.00	0	Mud-*Salicornia virginica*-*Distichlis spicata* interface	
	18	*Hordeum jubatum*	B
		Atriplex patula var. *hastata*	B
11.40	33	*Juncus gerardii*	B
		MHHW	
	59	*Salicornia virginica*	E
	63	*Festuca rubra*	B
	70	*Triglochin maritimum*	B
11.80	119	End of Marsh (ULM)	
		Hordeum jubatum	E
		Distichlis spicata	E
		Atriplex patula var. *hastata*	E
		Juncus gerardii	E
		Festuca rubra	E
		Triglochin maritimum	E
		Alnus rubra	B
	133	*Pseudotsuga menziesii*	B
		Polystichum munitum	B
15.00	136	EHW	
16.00	137.5	EHW +1	

* B = Begins, E = Ends


A
B
C
FEET ABOVE MLLW
ULM
MHHW
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
DISTANCE IN FEET

HARPER

WASHINGTON - 70 -

U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

South Colby - Harper, Yukon Harbor,
Puget Sound
Lat. 47° 31'.4; Long. 122° 31'.0

BENCH MARK 2 (1917) is a standard disk, stamped "NO 2 1917", set on top of prominent granite ivy covered boulder about 4 feet high and 8 feet in diameter, on knoll about 10 feet above road and close to seaward edge of bluff. It is one mile west of ferry landing at Harper, approximately 115 yards west of post office and store at South Colby, 37 feet north of center of main highway, 52½ feet west-southwest of southwest corner of first house west of post office, 65 feet east-southeast of pump in open field, 100 feet east of crossroad leading to Don Round Custom Boat Builders Shop. Elevation: 48.14 feet above mean lower low water.

BENCH MARK 3 (1934) is a standard disk, stamped "NO 3 1934", set in boulder projecting 6 inches above beach one mile west of ferry landing at Harper and 0.1 mile along private road north of South Colby Post Office. It is 86½ feet west of northwest corner of concrete and stone seawall, 21 feet east of line of piling that supported old dock, and 45 feet north of high waterline. Elevation: 8.66 feet above mean lower low water.

BENCH MARK 4 (1934) is a standard disk, stamped "NO 4 1934", set in top of granite boulder projecting one foot above ground, about 260 feet east of remains of former wharf, one mile west of ferry landing at Harper and 0.1 mile north of highway at South Colby. It is approximately 250 yards northwest of where highway leaves beach east of South Colby, 24 feet south of corner of seawall at steps, 2 feet northwest of 2-foot fir tree that has been trimmed, 11 feet west of trail leading up hill to house, and 4 feet higher than seawall. Elevation: 18.89 feet above mean lower low water.

BENCH MARK 5 (1952) is a standard disk, stamped "HARPER NO 5 1952", set in concrete floor at front of Harper Grocery and Filling Station. It is about 10 feet east of step in front of door, 2 feet south of southeast corner of building, 31 yards north of centerline of Harper Ferry Dock, and 8 yards west of seawall. Elevation: 15.90 feet above mean lower low water.

BENCH MARK 6 (1952) is a standard disk, stamped "HARPER NO 6 1952", set on top of seawall one foot above high tide, approximately 200 yards east of first point east of Yukon Harbor. It is about 31½ feet north-northwest of west corner of walk leading to house on slope, and 60 yards southeast of Harper 2 R.M. 1 (Bench Mark 10). Elevation: 14.35 feet above mean lower low water.

(OVER)

BENCH MARK 7 (1952) is a standard disk, stamped "HARPER NO 7 1952", set on top of seawall, 550 yards west-northwest of ferry landing at Harper. It is approximately ½ mile east of South Colby, in line with western front window of W. H. Worthly home and grey granite rock in his front yard, and 36 feet northeast of rock. House has large view window in living room on east side. Elevation: 14.46 feet above mean lower low water.

BENCH MARK 8 (1953) is a standard disk, stamped "HARPER NO 8 1952", set flush with top of seawall, 0.6 mile west of ferry landing at Harper, 165 feet northeast of intersection at Cornel Road (gravel road leading along beach on Harper Point) and highway. It is approximately 135 feet southwest of culvert through seawall, 8 yards southwest of point where curve in seawall joins tangent to northeast, and approximately 5 feet southeast of power pole from which lines cross beach gravel road. Elevation: 14.32 feet above mean lower low water.

BENCH MARK 10 (1952) is a standard reference mark disk, stamped "HARPER 2 RM 1 1934", set on top of seawall over concrete culvert and level with surface of gravel road leading along beach. It is about 300 yards northwest of ferry dock at Harper on Harper Point, 180 feet east of northeast corner of house with three small gables on east and west sides, and 39 feet northeast of east corner of eastern of two garages . Elevation: 14.50 feet above mean lower low water.

Mean lower low water at South Colby - Harper, Yukon Harbor, Puget Sound is based on 2 months of records, November - December 1952, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean higher high water	11.40
Mean high water	10.60
Mean tide level	6.70
Mean low water	2.80
Mean lower low water	0.00

The estimated highest water level to the nearest half foot is 15 feet above mean lower low water. The estimated lowest water level to the nearest half foot is 4½ feet <u>below</u> mean lower low water.

GROUNDWATER MOVEMENT DATA

Site: Harper

Date of Sampling: October 16, 1976

Height of Tide: 10.68

Height of MHHW: 11.40

Salinity of Harper tidal creek water: 18 °/oo - 21.5 °/oo

TIME:	11:40	12:05	12:34	1:02	Total Change	T°C	S °/oo	LOCATION:
Change in cm	0	0	0	0	0	--	--	T* A**
	0	+2.9	+1.0	+1.8	+5.70	12.2	8.1	T-1'

	11:15	12:03	12:35	12:59	Total Change	T°C	S °/oo	
Change in cm	0	0	0	0	0	--	--	T B
	0	0	-1.2	0	-1.2	--	--	T-1'

	11:10	12:13	12:36	12:53	Total Change	T°C	S °/oo	
Change in cm	0	0	0	0	0	--	--	T C
	0	+2.0	+1.1	+0.8	+3.9	12.0	7.0	T-1'

* T = Transition
** Transect

COMMUNITY COMPOSITION

HARPER
October 9, 1976

SPECIES	REPLICATES					
	I	II	III	IV	V	VI
Carex lyngbyei	5*	5	5	5	4	5
Distichlis spicata	1	1	1	1	1	1
Salicornia virginica	2	2	1	1	4	2
Triglochin maritimum						1
Atriplex patula				1		

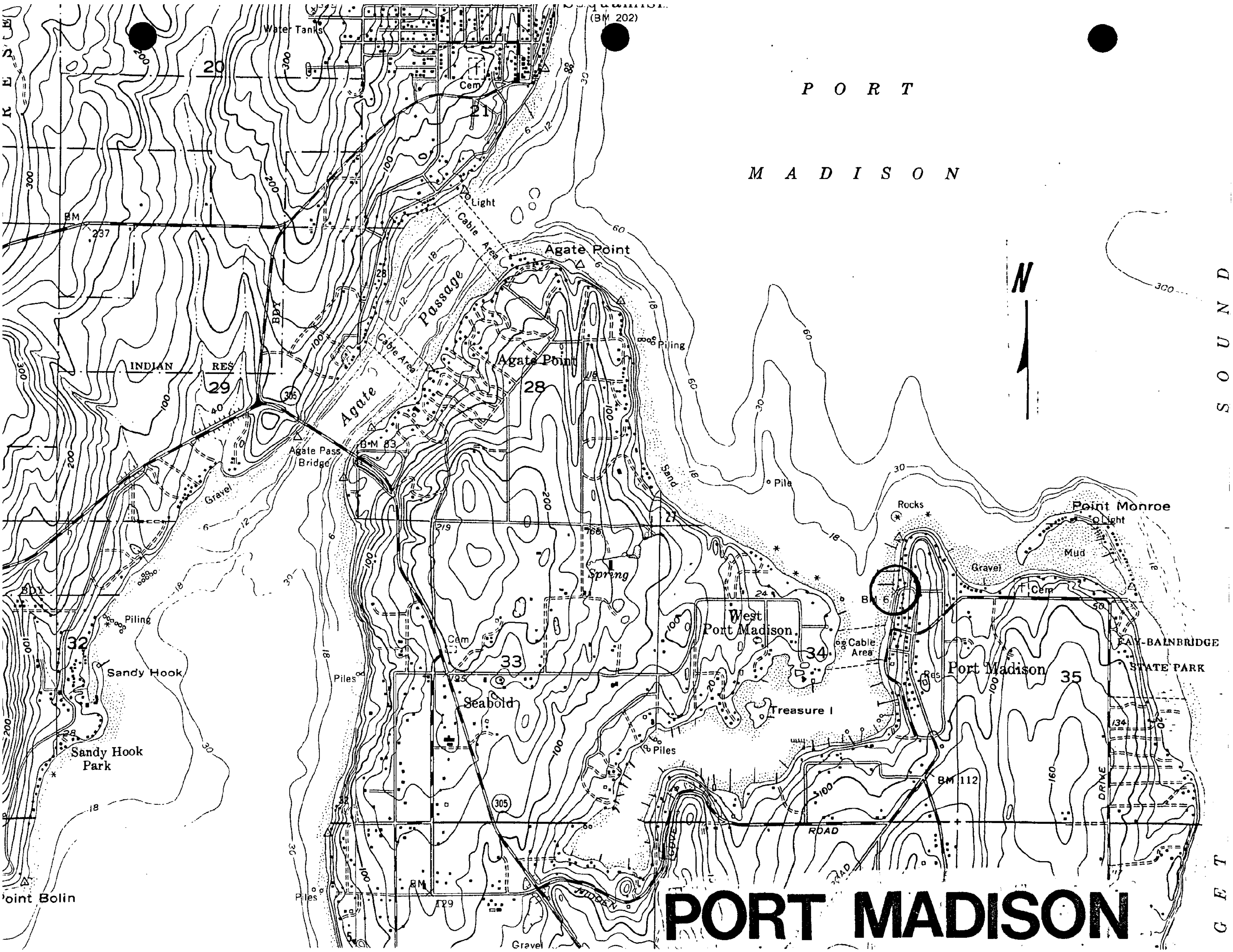
*Numbers correspond to percent coverage classification. See Table 1 , *Methods and Materials*.

PORT MADISON

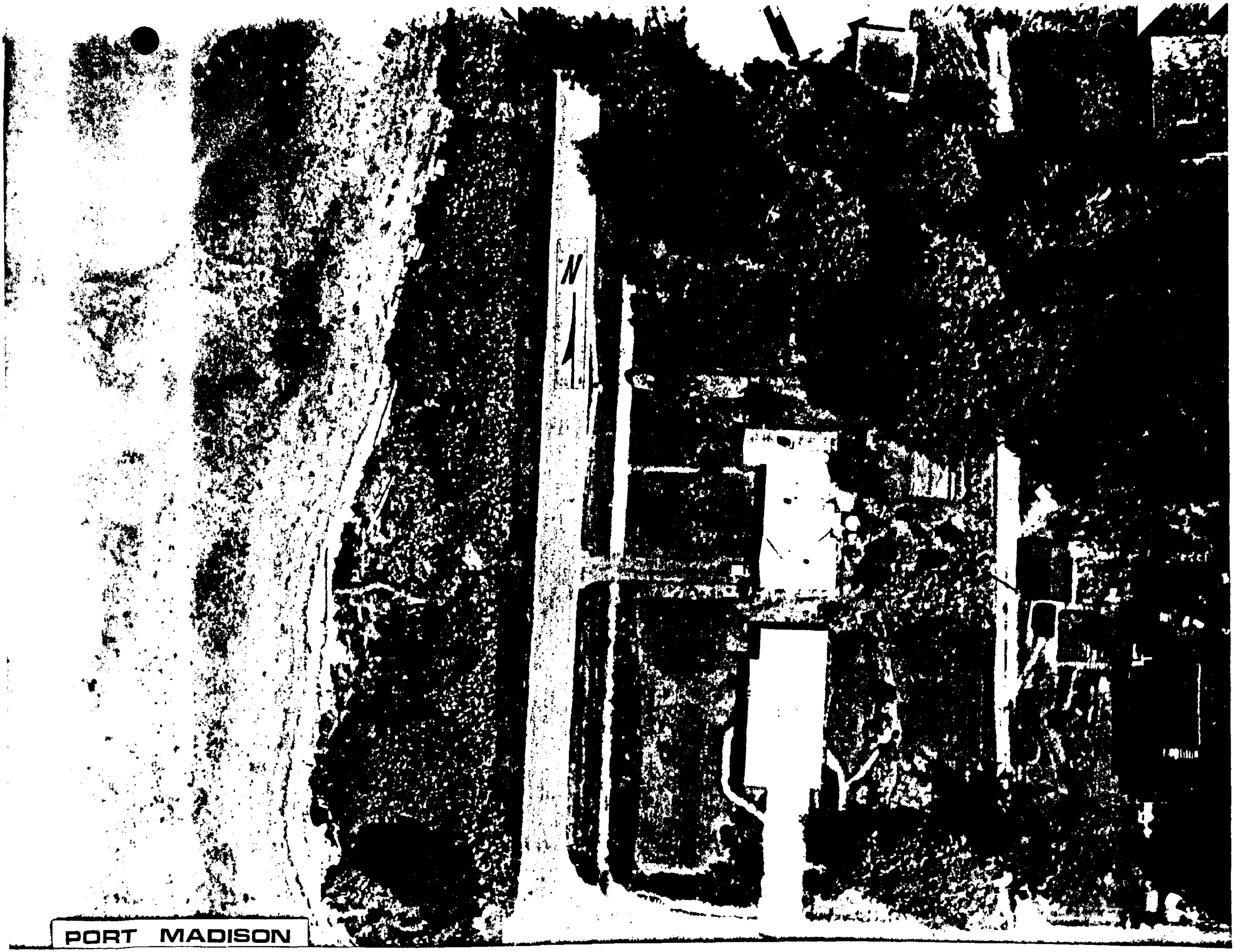
PORT MADISON MARSH

This marsh area abuts a cobble beach on the east side and a low bank on the west. The shoreward Salicornia-Distichlis zone characteristic of many marshes is absent here. However, four thousand feet south in a protected area of Port Madison this lower zone is present. Approximately three throusand feet north of the sampled area the cobble beach abuts a low bank cliff. Thus, the sampled area represents a wave energy setting at the higher end for marshes. The fore part of the marsh is a sand bar with Elymus mollis predominant. Along the upper shore and throughout the marsh are scattered logs. No streams or groundwater surface seepage was noted.

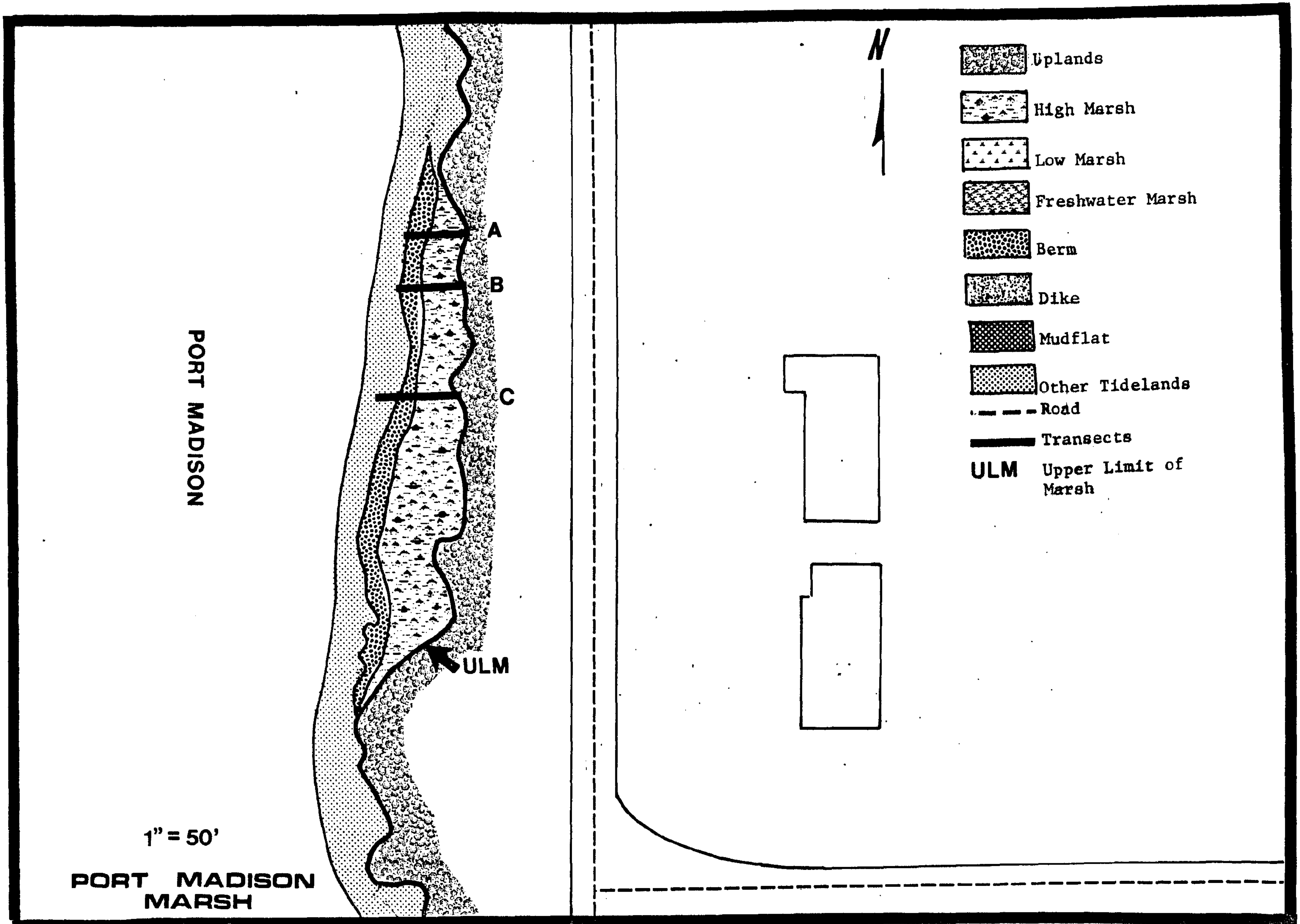
The aquatic areas of the encompassing Port Madison are primarily used for residential boat moorage and scientific research (WSDNR, 1974). The sampled marsh is not considered a major waterfowl habitat (WSDNR, 1974). The marsh area access is controlled by the local residents. This, combined with a stable accretion vs. erosion condition, is indicative that the marsh will continue in its present form.



PORT MADISON
PORT
MADISON
SOUND
N
Agate Point
Agate Passage
Agate Pass Bridge
Cable Area
Light
Piling
Sand
Pile
Rocks
Point Monroe
Mud
Gravel
Cem
West Port Madison
Port Madison
Treasure I
Seabold
Spring
Piles
INDIAN RES
Sandy Hook
Sandy Hook Park
Point Bolin
Water Tanks
(BM 202)
FAY-BAINBRIDGE STATE PARK
ROAD
DRIVE
BM 112
BM 83
BDY
20
21
28
29
32
33
34
35



PORT MADISON


PORT MADISON
A
B
C
ULM
N
Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM Upper Limit of Marsh
1" = 50'
PORT MADISON MARSH

SITE: Pt. Madison

TRANSECT NUMBER: A

DATE OF SAMPLING: Sept. 16, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
11.40 feet	38	MHHW	
11.91	41.5	Elymus mollis	B
		Distichlis spicata	B
	42.0	Distichlis spicata	E
	46.0	Vicia sp.	B
	49.0	Atriplex patula var. hastata	B
	54.5	Rubus discolor (overlapping)	B
	60.0	Sonchus arvensis	B
	61.0	Agrostis alba var. palustris	B
12.11	65.0	End of Marsh (ULM)	
		Elymus mollis	E
		Vicia sp.	E
		Atriplex patula var. hastata	E
		Sonchus arvensis	E
15.00	79.0	EHW	
16.00	80.0	EHW +1	

* B=Begins, E=Ends

SITE: Pt. Madison

TRANSECT NUMBER: B

DATE OF SAMPLING: Sept. 16, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
11.40 feet	40.5	MHHW	
12.54	43.5	*Distichlis spicata*	B
	50.0	*Sonchus arvensis*	B
	51.0	*Atriplex patula* var. *hastata*	B
	52.0	*Rubus discolor* (overlapping)	B
		Distichlis spicata	E
	56.0	*Vicia* sp.	B
	65.0	*Agrostis alba* var. *palustris*	B
	69.0	*Poa* sp.	E
	70.0	*Rubus laciniatus*	B
	71.0	*Elymus mollis*	E
		Sonchus arvensis	E
		Atriplex patula var. *hastata*	E
		Vicia sp.	E
		Agrostis alba var. *palustris*	E
11.70	74.0	End of Salt Marsh (ULM)	
	75.0	*Solanum dulcamara*	B
	75.0	*Acer macrophyllum*	B
15.00	83	EHW	
16.00	84	EHW +1	

* B=Begins, E=Ends

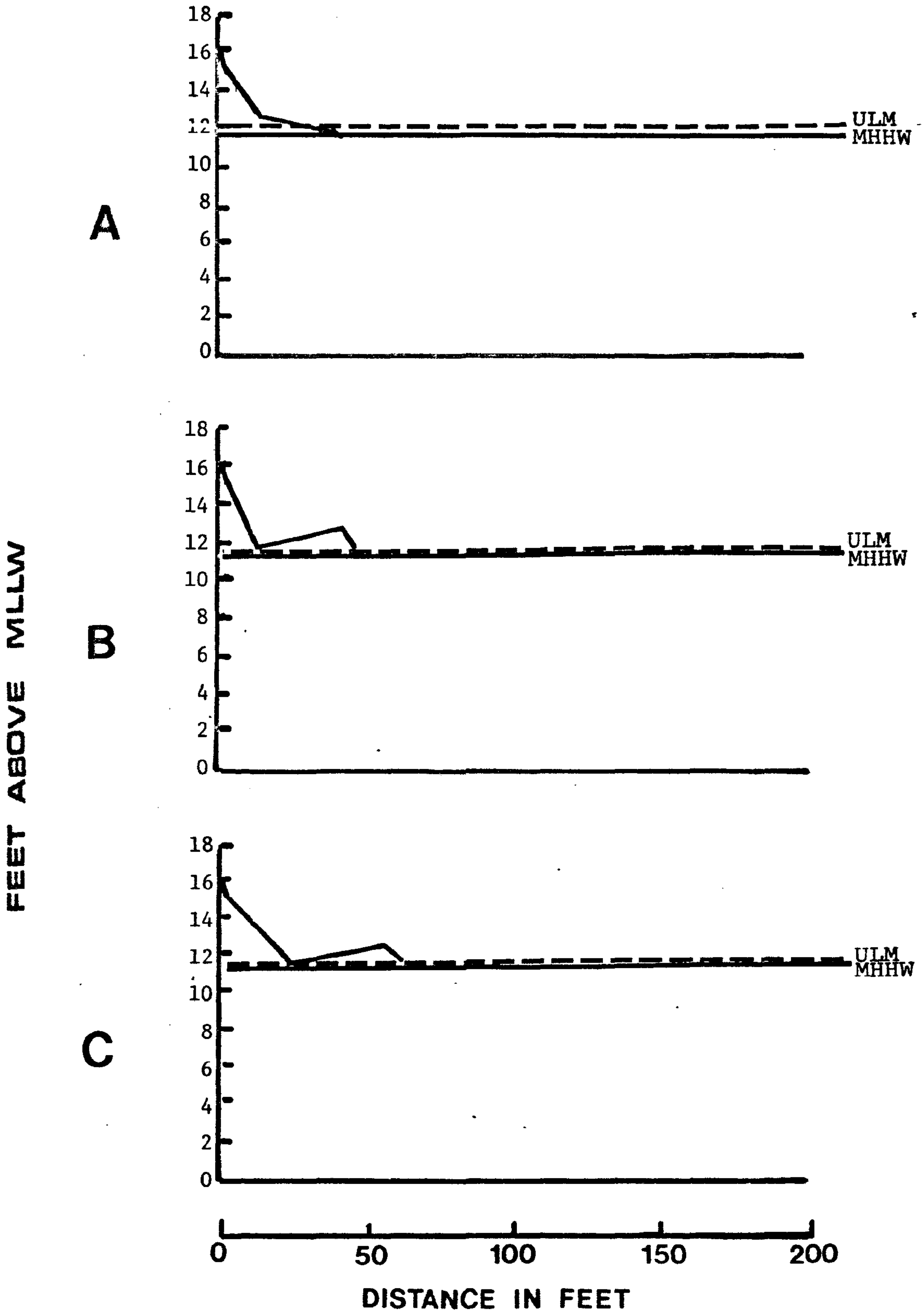
SITE: Pt. Madison

TRANSECT NUMBER: C

DATE OF SAMPLING: Sept. 16, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
11.40 feet	36	MHHW	
12.54	44	*Salicornia virginica*	B & E
	45	*Elymus mollis*	B
		Atriplex patula var. *hastata*	B
		Distichlis spicata	B
	48	*Sonchus arvensis*	B & E
	49	*Grindelia integrifolia*	B & E
	59	*Convolvulus sepium*	B
	66	*Agrostis alba* var. *palustris*	B
	71	*Hordeum brachyantherum*	B & E
11.44	72	Outer Edge of Terrestrial Vegetation	
	74	End of Salt Marsh (ULM)	
		Elymus mollis	E
		Atriplex patula var. *hastata*	E
		Distichlis spicata	E
		Convolvulus sepium	E
	76	*Agrostis alba* var. *palustris*	E
15:00	92.5	*Acer macrophyllum*	B
		EHW	
16:00	94.5	EHW +1	

* B=Begins, E=Ends



PORT MADISON

U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

Port Madison, Bainbridge Island,
Puget Sound
Lat. 47° 42'.3; Long. 122° 31'.5

BENCH MARK 3a (1934) is a ½-inch copper bolt set flush in top of light-colored medium-sized boulder at bottom of old stairway leading down bank on beach below high waterline, 142 feet south of south piling line of ruins of Kitsap County Transportation Company Dock. It is about 1 foot above beach level, 18 feet out from base of bluff, and 102 feet south of Bench Mark 5 (1944). Elevation: 11.33 feet above mean lower low water.

BENCH MARK 1 (1934) is a standard disk, stamped "NO 1 1934), set in concrete block, 10 inches square, and 30 inches long, imbedded in sand and gravel beach, and projecting 6 inches above beach level. It is 6 feet out from base of bluff at about storm high waterline, 85 feet north of north line of piling of ruins of Kitsap County Transportation Company Dock, and 140 feet north of Bench Mark 5 (1944). Elevation: 11.69 feet above mean lower low water.

BENCH MARK 5 (1944) is a metal plug set in top of 2½-foot square boulder on beach to south of ruins of Kitsap County Transportation Company Dock. It is 40 feet south of south line of piling of dock, 102 feet north of Bench Mark 3a (1934), 22 feet out from base of bluff, and 1½ feet above beach level. Elevation: 11.01 feet above mean lower low water.

Mean lower low water at Port Madison, Bainbridge Island, is based on 78 high waters and 78 low waters, June 27 - August 6, 1934, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean higher high water	11.40
Mean high water	10.50
Mean tide level	6.65
Mean low water	2.80
Mean lower low water	0.00

The estimated highest water level to the nearest half foot is 15 feet above mean lower low water. The estimated lowest water level to the nearest half foot is 4½ feet below mean lower low water.

GROUNDWATER MOVEMENT DATA

SITE: Port Madison

DATE OF SAMPLING: October 12, 1976

Height of Tide: 10.80

Height of MHHW: 11.40

Salinity of Port Madison Waters: 24 $^{o}/oo$

TIME:	6:15	6:30	7:00	7:20	Total Change	T°C.	S°/oo	LOCATION:
Change in cm	0	0	-1.8	+.5	-1.3	13.75	.5	T* **A** **
	0	0	0	0	0	--	--	T +1'

	6:15	6:30	7:00	7:20	Total Change	T°C	S °/oo	
Change in cm	0	+0.4	+1.2	0	+1.6	8.0	24.0	T **B**
	0	0	0	0	0	--	--	T +1'

	6:15	6:30	7:00	7:20	Total Change	T°C	S °/oo	
Change in cm	0	0	0	+.3	+.3	12.0	0.5	T **C**
	0	0	0	0	0	--	--	T +1'

* T = Transition
** Transect

NISQUALLY FLATS

NISQUALLY

The Nisqually river delta was at one time extensively diked for agricultural purposes. Today it is a National Wildlife Refuge and is used as a scientific study area by The Evergreen State College. The area is now reverting to a brackish marsh, as the dikes deteriorate.

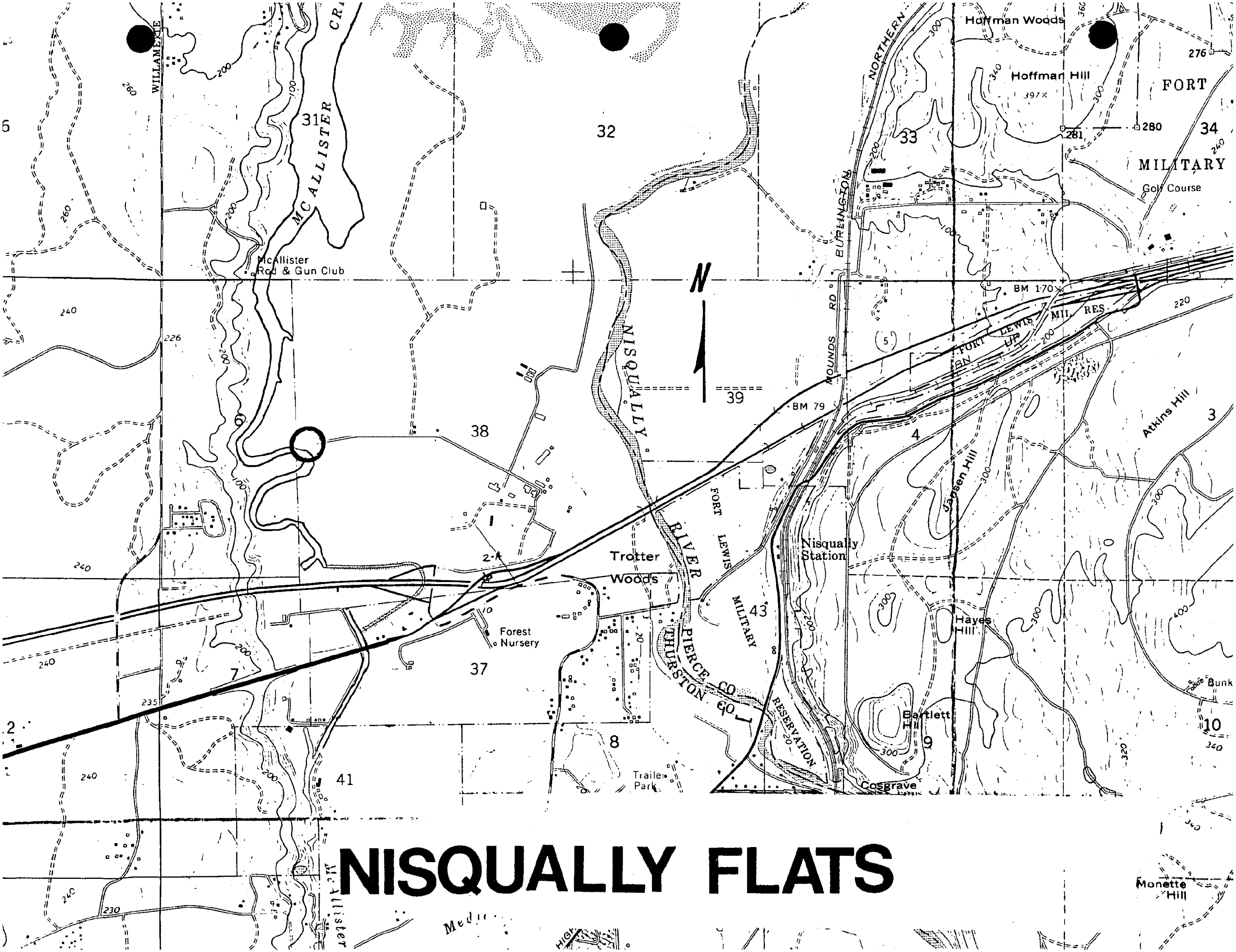
The region studied was a disturbed site on the west side of McAllister Creek. Transects B and C cross a low dike that runs parallel to the creek.

McAllister Creek is diluted with fresh water from the adjacent uplands and freshwater seepage from behind the dikes. However, this water is mixed with sea water at high tide so that large salinity fluctuations occur. Many of the trees are dead or dying except on the top of dikes which extend above high water.

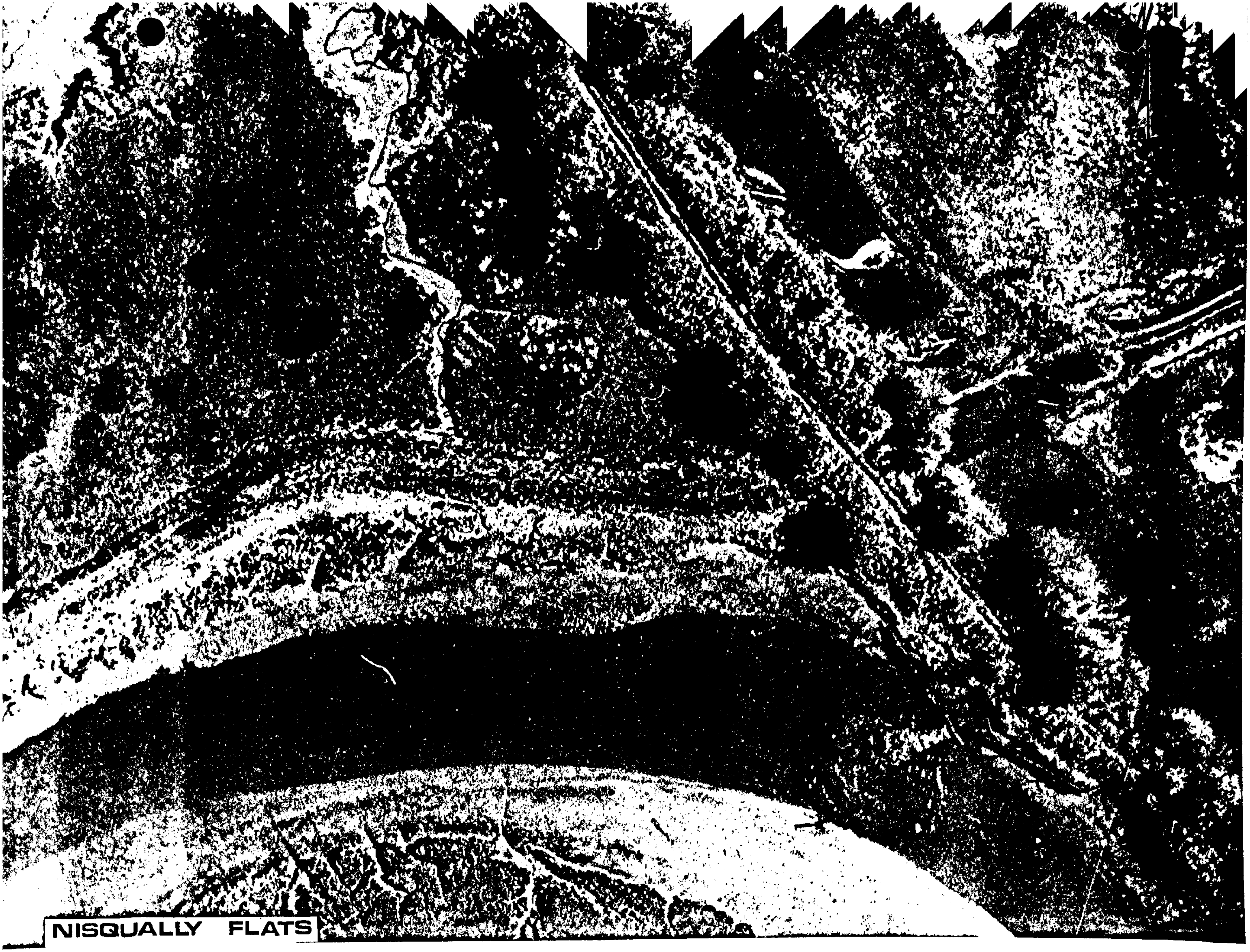
The low dike is almost perpendicular with the main dike, as such there is a free exchange of tidal waters along the main dike. Thus the three replicates represent the main dike's transition. Transects B and C by crossing to low perpendicular dike provide additional information about its tidal height and flora.

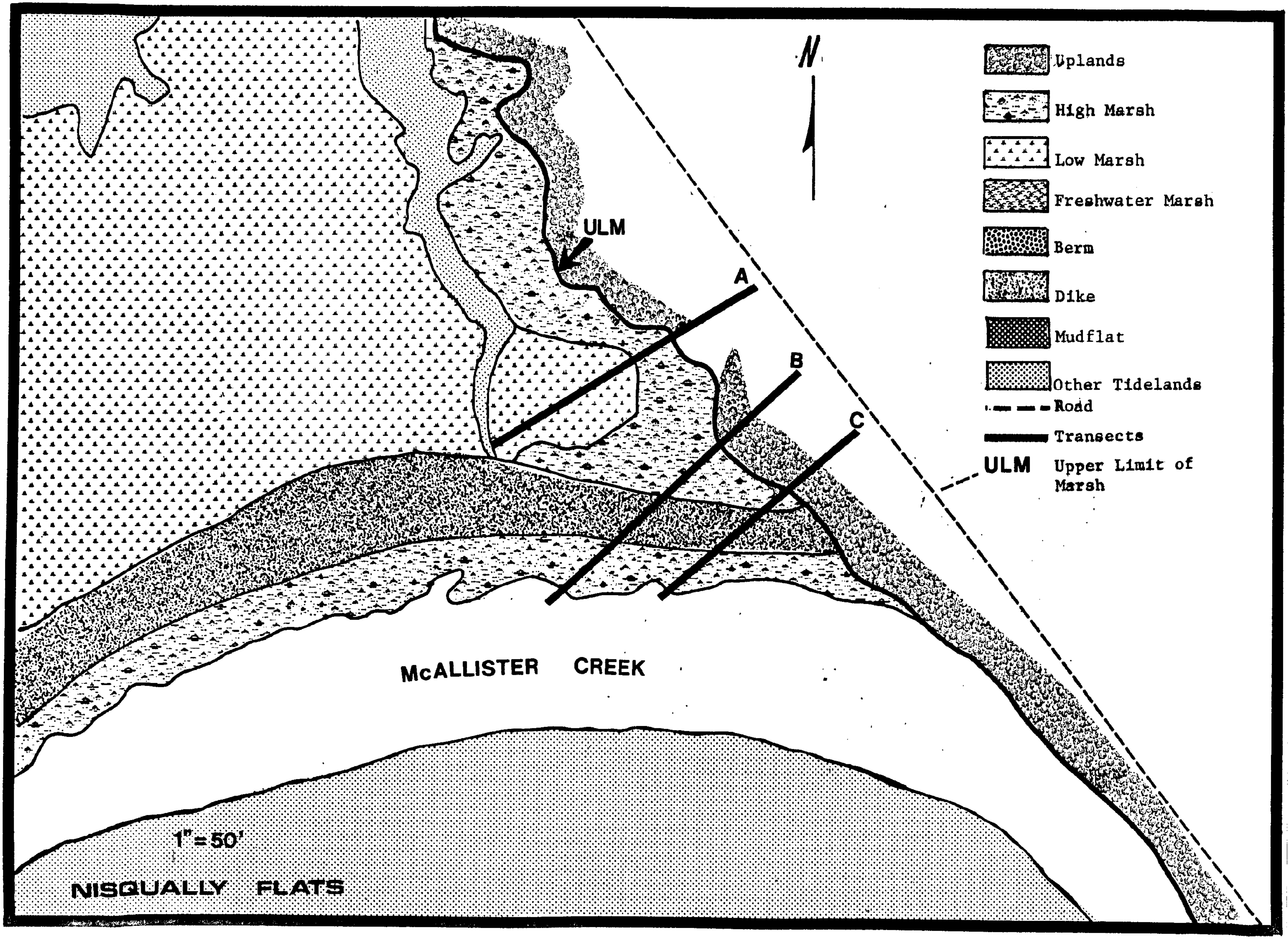
The area has been extensively surveyed and several tidal benchmarks have been placed by U.S. Fish and Wildlife engineers surveying off of the Dupont tidal benchmark. The Dupont benchmark tidal height is based on 16 days of data in 1935. Thus the NOAA estimate of MHHW may be up to 0.138 feet in error using Swanson's (1974) figures. This error is compounded by the fact that the sampled area is located up the tidal creek which may account for some of the variability of the ULM-MHHW distance between transects A, B, and C.

As the Nisqually delta area reverts to a brackish water marsh, it would be interesting to follow the change in species composition to obtain information regarding the rate and nature of their ontogeny.



NISQUALLY FLATS


NISQUALLY FLATS



N
Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM
Upper Limit of Marsh
ULM
A
B
C
McALLISTER CREEK
1" = 50'
NISQUALLY FLATS

SITE: Nisqually

TRANSECT NUMBER: A

DATE OF SAMPLING: Oct.1, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
12.19	0 feet	Beginning of Vegetation	
		Carex cf. lyngbyei	B
		Jaumea carnosa	B
		Atriplex patula L. var. hastata	B
		Distichlis spicata	B
		Hordeum brachyantherum	B
		Polygonum fowleri	B
		Agrostis alba var. palustris	B
	9	Triglochin maritimum	B
	10	Juncus gerardii	B
	39	Triglochin maritimum	E
	46	Hordeum bracnyantherum	E
	48	Salicornia virginica	B
	58	Carex cf. lyngbyei	E
		Juncus balticus	B
	59	Festuca rubra	B
		Distichlis spicata	E
		Salicornia virginica	E
		Juncus gerardii	E
		Atriplex patula	E
		Jaumea carnosa	E
		Polygonum fowleri	E
	60	Juncus balticus	E
		Achillea millefolium var. californica	B
14.03	62.5		
	67	Vicia sp. (dead)	B
15.02		(ULM)	
		Pyrus fusca	B
	68	Agrostis alba var. palustris	B
		Agropyron repens	B
16.03	72		
	73	Holcus mollis	B
	77	Symphoricarpos albus var. laevigatus	B
		Rosa sp.	B
17.24	79		
18.20	92	Top of Dike	

* B = Begins E = Ends

SITE: Nisqually

TRANSECT NUMBER: B

DATE OF SAMPLING: Oct. 1, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
9.73 feet	0 feet	Beginning of Vegetation	
		Distichlis spicata	B
	2	Grindelia integrifolia var. macrophylla	
	3	Jaumea carnosa	B
	6	Salicornia virginica	B
	10	Salicornia virginica	E
	15	Atriplex patula	B
	20	Triglochin maritimum	+
	23	Dike	E
	24	Grindelia integrifolia	E
	24-29	90% cover of Atriplex patula	
	27	Hordeum brachyantherum	B
		Festuca rubra	B
	29	Jaumea carnosa	E
		Atriplex patula var. hastata	E
		Distichlis spicata	E
	34	Holcus mollis	B
	34	Cirsium vulgare	+
		Dike levels Off	
	36	Plantago lanceolata	B
	39	Achillea millefolium var. californica	B
52	40.5		
	42	Bromus mollis	E
	45	Plantago lanceolata	E
	48	Vicia sp.	+
	49	Achillea millefolium var. californica	E
	51	Holcus mollis	E
	52	Atriplex patula var. hastata	
	55	Juncus gerardii, Polygonum fowleri	B
	56	Atriplex patula patch	
13.03	57		
	58	Distichlis spicata	B
		Salicornia virginica	B
	63	Agrostis alba var palustris	B
	65	Jaumea carnosa	B
	68	Spergularia canadensis	B
	82	Carex cf. lyngbyei	+
	81	Triglochin maritimum	B
12.88	119	Distichlis spicata	E
		Triglochin maritimum	E
		Juncus gerardii	E
		Polygonum fowleri	E
		Jaumea carnosa	E
		Salicornia virginica	E
	123	Agropyron repens	E
13.88	124	(ULM)	
		Rosa sp.	B
		Cirsium vulgare	B
14.88	126		
		Holcus mollis	B
	128	Pyrus fusca	B

* B=Begins, E=Ends, + = single plant

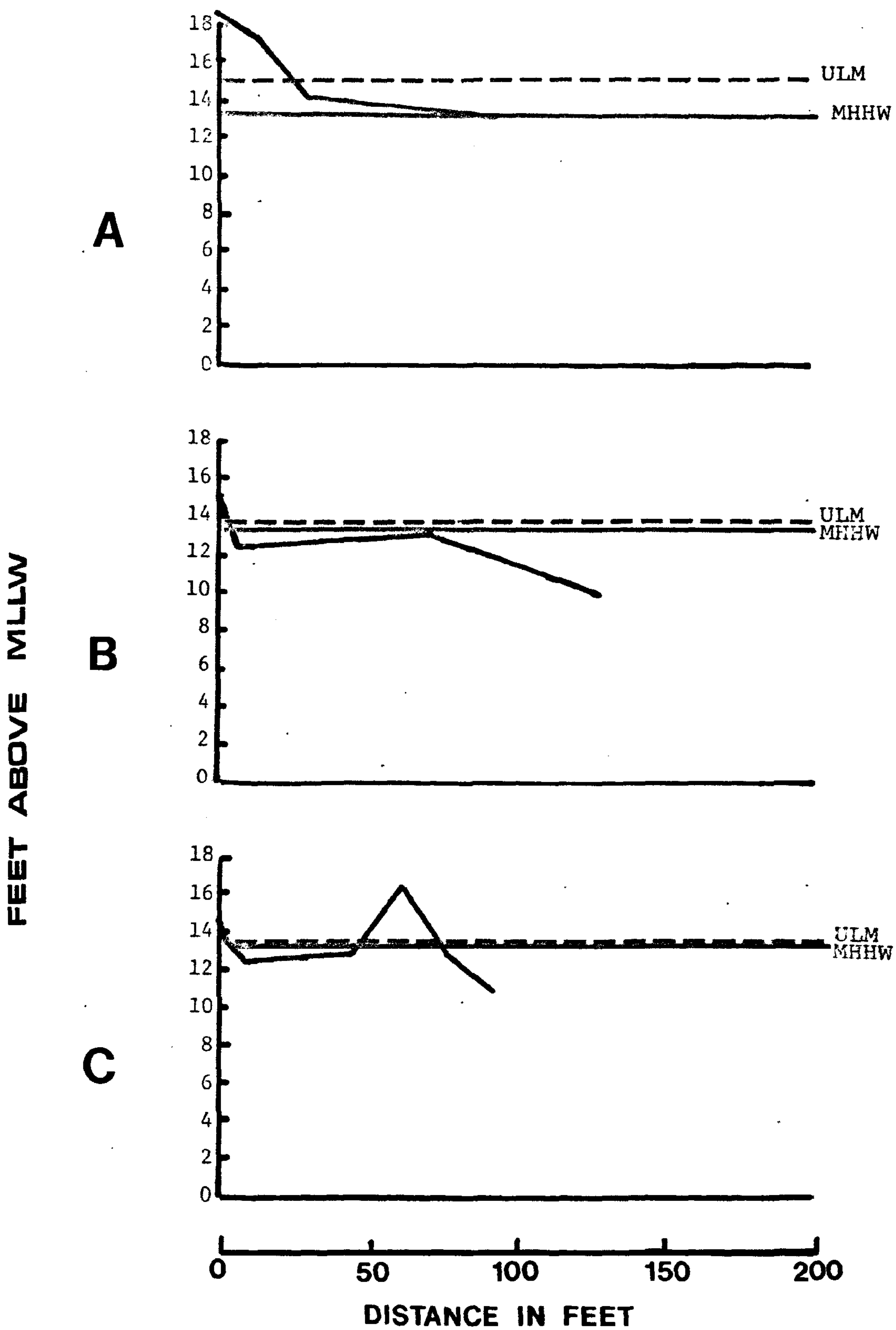
SITE: Nisqually

TRANSECT NUMBER: C

DATE OF SAMPLING: Oct. 1, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
11.20	0 feet	Beginning of Vegetation	
		Distichlis spicata	B
	3	Spergularia canadensis	+
	6	Atriplex patula var. hastata	B
	8	Salicornia virginica	B
	13	Grindelia integrifolia var. macrophylla	B
	21	Jaumea carnosa	B
	24-31	75% cover of Atriplex patula	
12.84	26		
	27	Salicornia virginica	E
	28	Grindelia integrifolia	E
		Distichlis spicata	E
	31	Atriplex patula var.hastata	E
		Jaumea carnosa	E
		Agropyron repens	B
	35	Agrostis alba var. palustris	+
	35.5	Top of Slope	
16.11	39		
	40	Bromus mollis	+
	42	Holcus mollis	B
	46	Cirsium vulgare	+
	49	Pyrus fusca	+
		Edge of Berm (Downslope begins)	
	51	Festuca rubra	+
	53	Agropyron repens	E
		Atriplex patula var. hastata	B
	55	Hordeum brachyantherum	+
		Juncus gerardii	B
		Distichlis spicata	B
12.87	57		
	60	Salicornia virginica	B
		Jaumea carnosa	B
	65	Juncus gerardii	E
	70	Triglochin maritimum	+
	88	Atriplex patula	E
		Salicornia virginica	E
		Jaumea carnosa	E
		Beginning of Bog	
12.40	91		
	92	Bog ends	
	92-98.9	Mud with Pyrus fusca over (canopy)	
13.40	98.9	(ULM)	
14.40	99	Pyrus fusca	B

* B = Begins, E = Ends, + = single plant



NISQUALLY FLATS

8/4/69 WASHINGTON - 88

U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
COAST AND GEODETIC SURVEY

TIDAL BENCH MARKS

Dupont, Nisqually Reach, Puget Sound
Lat. 47° 07'.1; Long. 122° 40'.0

BENCH MARK 3 (1935) is a standard disk, stamped "NO 3 1935", set in 3-foot square concrete foundation block for wooden tower structure supporting overhead conveyor cable leading from Dupont factory to wharf. There are six such block on beach and bench mark is in northeastern one, farthest inshore. Elevation: 15.75 feet above mean lower low water.

BENCH MARK 4 (1935) is a standard disk, stamped "NO 4 1935", set in top of concrete coulvert under Northern Pacific Railway tracks a short distance south of Dupont narrow gage railroad. It is on inner (eastern) end of culvert, inside Dupont property. Elevation: 15.50 feet above mean lower low water.

BENCH MARK 5 (1944) is a 2-inch iron rod with deep cross carved across top and driven firmly in gound about 80 yards up ravine from Northern Pacific Railway tracks. It is about 16 feet north of north rail of narrow gage track running to Dupont Plant and 190 feet west of gate No. 8 into grounds. Elevation: 23.46 feet above mean lower low water.

Mean lower low water at Dupont Nisqually Reach is based on 31 high waters and 31 low waters, September 25 - October 11, 1935, reduced to mean values. Elevations of other tide planes referred to this datum are as follows:

	Feet
Mean higher high water	13.40
Mean high water	12.50
Mean tide level	7.70
Mean low water	2.90
Mean lower low water	0.00

The estimated highest water level to the nearest half foot is 17 feet above mean lower low water. The estimated lowest water level to the nearest half foot is 4½ feet below mean lower low water.

ULM ELEVATIONS

Nisqually

13.40 ft.
14.36 "
13.38 "
13.58 "
13.65 "
15.41 "
15.92 "
14.82 "
14.30 "
14.43 "
14.95 "
15.13 "
13.88 "
15.03 "

$\bar{X} = 14.45$

$S = .80$

GROUNDWATER MOVEMENT DATA

Site: Nisqually

Date of Sampling: October 1, 1976

Height of Tide:

Height of MHHW: 13.40

Salinity of McAllister Creek Wasters: 9.9 $^{o}/oo$

TIME:	1:11	1:53	2:20	2:52	3:12	3:32	4:07	TOTAL CHANGE	T°C	S°/oo	Location
CHANGE	0	+1.7	+1.5	+0.6	+0.7	-0.5	0	4	17	1.5	T* -1'
IN CM	0	0	0	0	0	0	0	0	--	--	T A**

	1.15	1:50	2:21	2:53	3:11	3:32	4:00	TOTAL CHANGE	T°C	S°/oo	
CHANGE	0	+27.7	+6.61	+1.9	0	0	-0.3	35.91	16	8.5	T - 1'
IN CM	0	0	0	0	0	0	0	0	--	--	T B

		1:52	2:22	2:54	3:05	3:30	4:05	TOTAL CHANGE	T°C	S°/oo	
CHANGE	0	0	+1.2	+0.2	+0.4	-0.5	0	1.3	18.5	11.2	T - 1'
IN CM		0	+1.3	+1.4	0	+0.2	+0.8	3.7	18.1	2.5	T C

*T = Transition

** Transect

COMMUNITY COMPOSITION

NISQUALLY
October 1, 1976

SPECIES	REPLICATES					
	I	II	III	IV	V	VI
Jaumea carnosa	3*	2.5	2	2	4	
Distichlis spicata	4.5	5		4	3	5
Salicornia virginica	2	1	2.5		2	
Triglochin maritimum	1			1		
Juncus gerardii			3.5			3
Atriplex patula				1	1	1
Agrostis alba				1		1
Hordeum brachyantherum						1
Spergularia canadensis	1	1				

*Numbers correspond to percent coverage classification. See Table 1, Methods and Materials.

SKAGIT FLATS

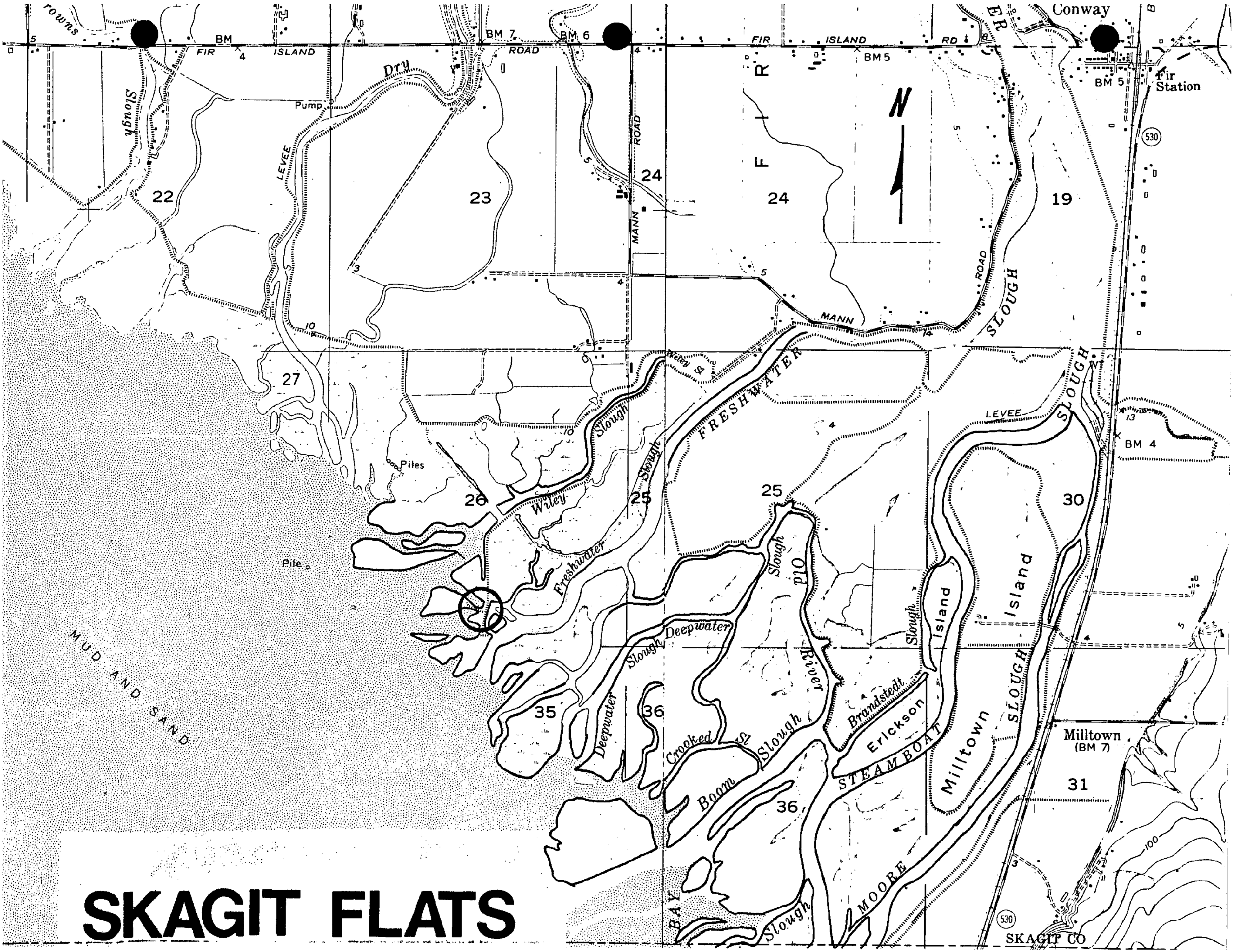
SKAGIT FLATS

The Skagit site was the only freshwater marsh subject to tidal action that was sampled. Based on topography alone it matches the other marsh areas with their tidal creeks and gentle berms. The salinity of the surface water approaches 1 to 2 ppt with up to 8 ppt found at the creeks bottom indicating the presence of a salt wedge. The predominance of freshwater associated with the tidal fluctuations is conducive to the growth of freshwater plants.

The vegetation along the small fore-dike was variable and obviously dominated by marsh plants. Therefore this area was used for the base line. Instead of seaweeds and eelgrass in the tidal creeks as is common in salt marshes, there was Myriophllum cf. spicatum, a freshwater plant. The upper zones were characteristically vegetated with Carex cf. lyngbyei, Potentilla pacifica, and Scirpus acutus. The upper zone ending at the ULM was for the most part a solid band of the cattail Typha latifolia.

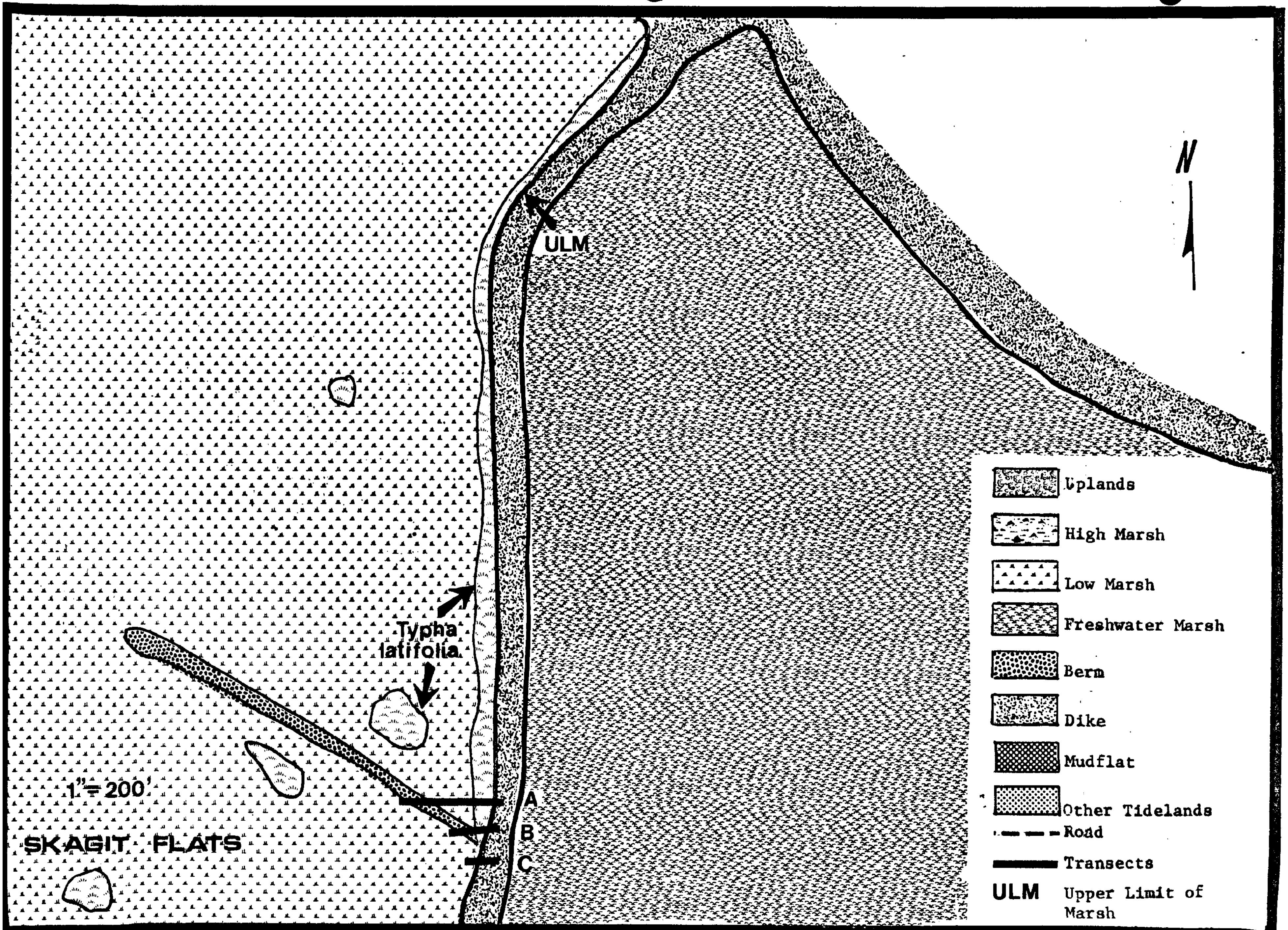
The Skagit Flats is an extensive waterfowl area. Most of the area is managed as a wildlife refuge by the Department of Game and it is utilized as a scientific research area.

The sample site may or may not entirely be representitive. because it represents a small area of the Skagit Flats. For example, along the North Fork of the Skagit River the transition to uplands is not pronounced prior to the change to a truly riparian environment. Also, the continuous dike system separating the marsh areas from the agricultural land on the river delta modifies any natural transition that might occur without the dikes. The rapid transition from _Typha latifolia_ to upland vegetation, although characteristic of Skagit is probably due to the presence of the steep slopes of the dikes.



SKAGIT FLATS


SKAGIT FLATS


N
ULM
Typha latifolia
A
B
C
1" = 200'
SKAGIT FLATS
Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM Upper Limit of Marsh

SITE: Skagit

TRANSECT NUMBER: A

DATE OF SAMPLING: Oct. 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT *	
(height to be added when tidal elevations available)	0 feet	Carex cf. lyngbyei	B
	31	Scirpus acutus	B
	43	Typha latifola	B
	56	Carex cf. lyngbyei	E
		Scirpus acutus	E
	61	Aster sp.	B
	71	Lycopus americanus	+
	72.5	Rorippa islandica	+
	86	Epilobium cf. watsonii	+
	95	Impatiens noli-tangere	
	99	Rubus spectabilis	B
	100	End of Marsh (ULM)	
		Typha latifola	E
	107	Rubus spectabilis	E
		Holcus mollis	B
	109	Alnus rubra	B

* B = Begins, E = Ends
\+ = single plant

SITE: Skagit

TRANSECT NUMBER: B

DATE OF SAMPLING: Oct. 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT *	
(height to be added when tidal elevations available)	0 feet	Carex cf. lyngbyei	B
	31	Lilaeopsis occidentalis	B
	37.5	Lilaeopsis occidentalis	E
		Carex cf. lyngbyei	E
		Potentilla pacifica	B
		Aster sp.	B
		Epilobium cf. watsonii	B
		Typha latifolia	B
	58.5	Typha latifolia	E
		End of Marsh (ULM)	
	59.	Vicia gigantea	B
	63	Salix sp.	B
	69	Festuca rubra	B
	71	Alnus rubra	B
	75	Lonicera involucrata	B
	82	Holcus mollis	B
		Agrostis alba var. palustris	B

* B = Begins, E = Ends

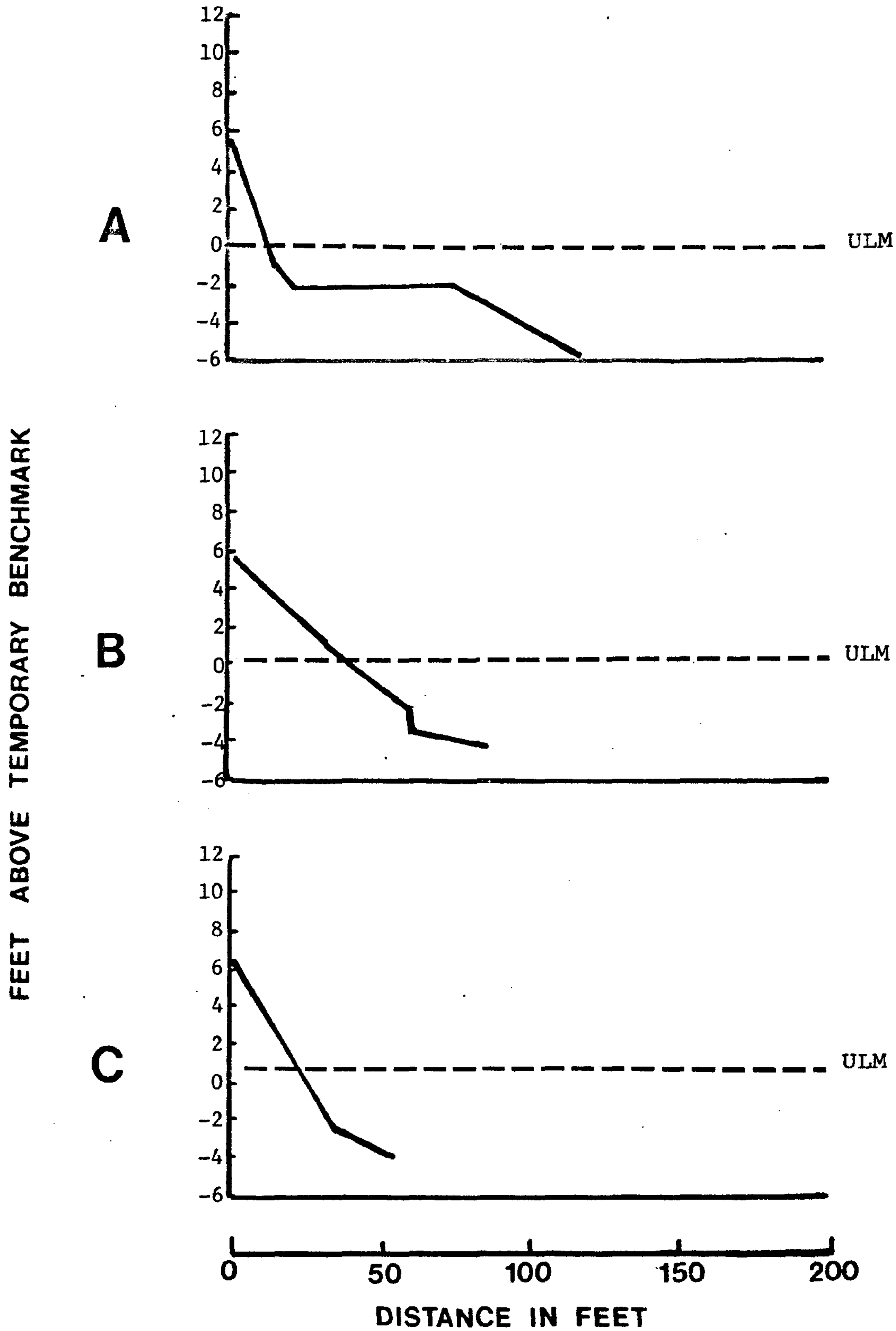
SITE: Skagit

TRANSECT NUMBER: C

DATE OF SAMPLING: Oct. 9, 1976

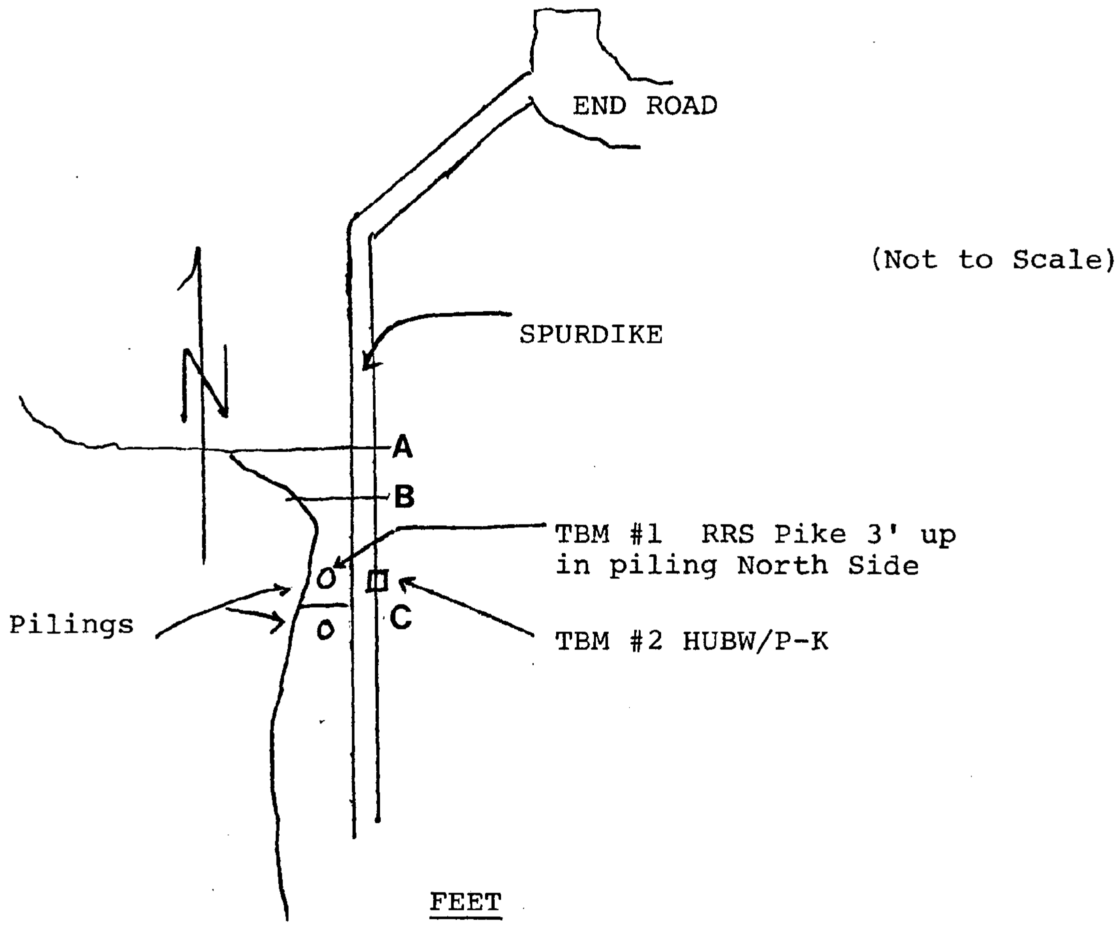
TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT *	
(height to be added when tidal elevations available)	0 feet	Carex cf. lyngbyei	B
	3	Scirpus acutus	B
	16	Scirpus acutus	E
	20	Potentilla pacifica	B
		Lotus corniculatus	B
	22	Aster sp.	B
	22.5	Plantago lanceolata	B
		Juncus balticus	B
	23	Agropyron repens	B
	24	Carex cf. lyngbyei	E
	26	Epilobium cf. watsonii	B
	28	Vicia gigantea	B
	30	Festuca rubra	B
	32	End of Marsh (ULM)	
		Equisetum arvense	+
		Potentilla pacifica	E
	29	Salix sp.	B
	34	Lotus corniculatus	E
	39	Holcus mollis	B
	42	Spergularia macrotheca	+
	48	Agrostis alba var. stolonifera	B

* B = Begins, E = Ends
+ = single plant



SKAGIT FLATS

"Fish and Wildlife Headquarters Dike"



FEET

-.98 = TBM #1 - ULM(A transect)

8.18 = TBM #2 - TBM #1

6.53 = TBM #2 - ULM(ULM (B transect)

5.72 = TBM #2 - ULM (C transect)

Position of ULM on profiles relative to TBM.

ULM ELEVATIONS

Skagit

8.87 ft.
11.01 "
10.53 "
11.00 "
10.10 "
10.30 "
8.30 "
9.00 "
9.90 "
10.70 "
10.60 "
10.80 "
10.10 "
9.80 "
10.3 "
10.1 "

$\bar{X}$ = 10.09 *

S = .78

Normalized to 0 in text.

GROUNDWATER MOVEMENT DATA

SITE: Skagit

Date of Sampling: October 9, 1976

Height of Tide: 9.4

Height of MHHW:

Salinity of intertidal creek waters: 1°/oo - 2°/oo

TIME:	14:40	16:27	16:43	17:37	17:46	TOTAL CHANGE	T°C	S°/oo	LOCATION:
CHANGE IN CM	0	+0.9	+0.5	Flooded	Flooded	N/A	15.3	1	T* - 1'
	0	+3.6	+1.6	+51.9	+1.7	+58.80	15.3	1	T **A****
	0	+6.4	+1.7	+7.5	+3.0	+18.60	15.0	0.5	T + 1'

		16:25		17:27		TOTAL CHANGE	T°C	S°/oo	
CHANGE IN CM		Flooded		Flooded		N/A	15.3	1	T - 1'
		Flooded		Flooded		N/A	15.3	1	T **B**
		0		+20		+20	15.3	0.5	T + 1'

		16:22		17:37		TOTAL CHANGE	T°C	S°/oo	
CHANGE IN CM		Flooded		Flooded		N/A	15.3	1	T - 1'
		Flooded		Flooded		N/A	15.3	1	T **C**
		0		+80		+80	15.0	0.5	T + 1'

* T = Transition
** Transect

COMMUNITY COMPOSITION

SKAGIT
October 8,1976

SPECIES	REPLICATES					
	I	II	III	IV	V	VI
Typha latifolia	5*	6	6	5	6	6

*Numbers correspond to percent coverage classification. See Table 1 , Methods and Materials.

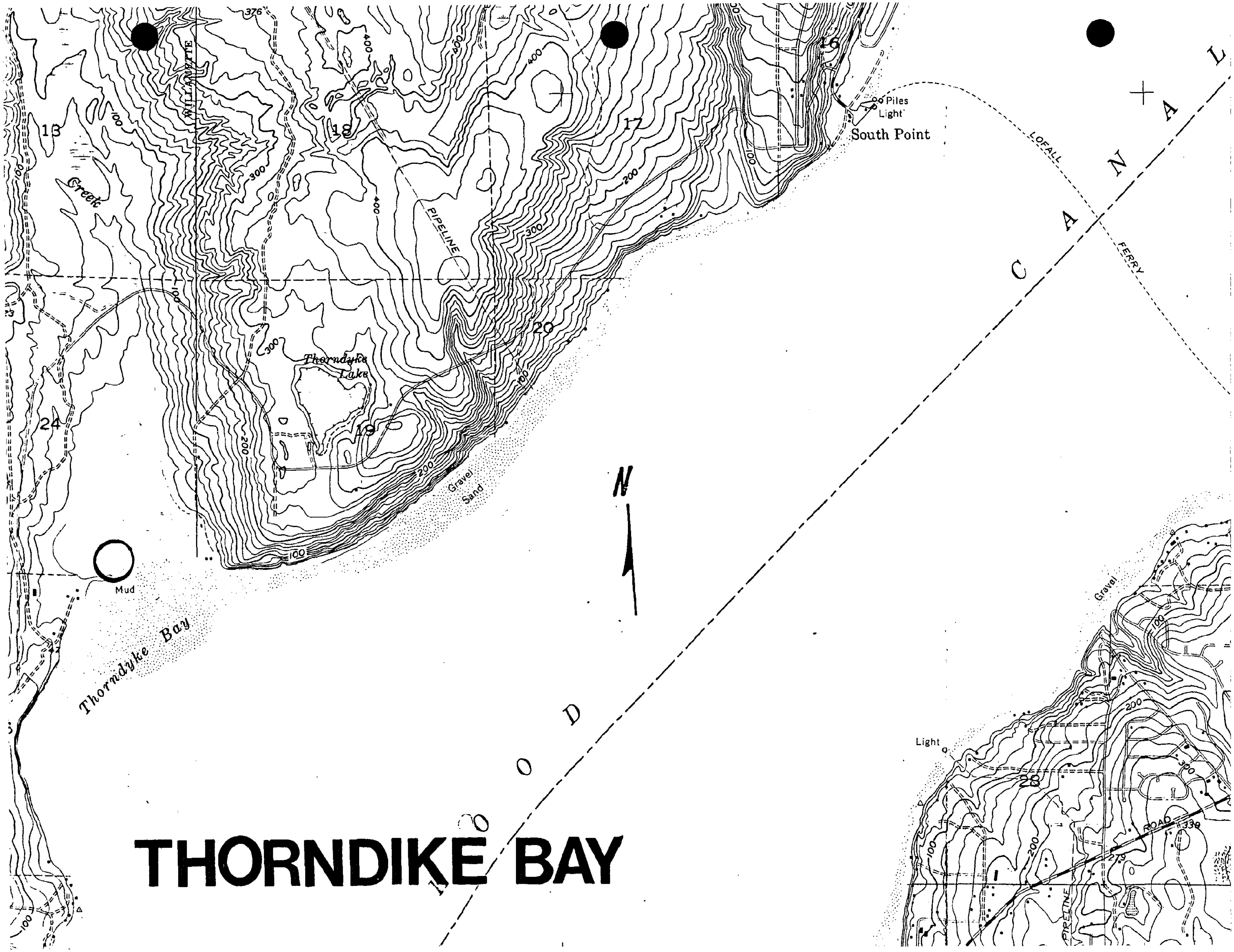
THORNDIKE BAY

THORNDIKE BAY

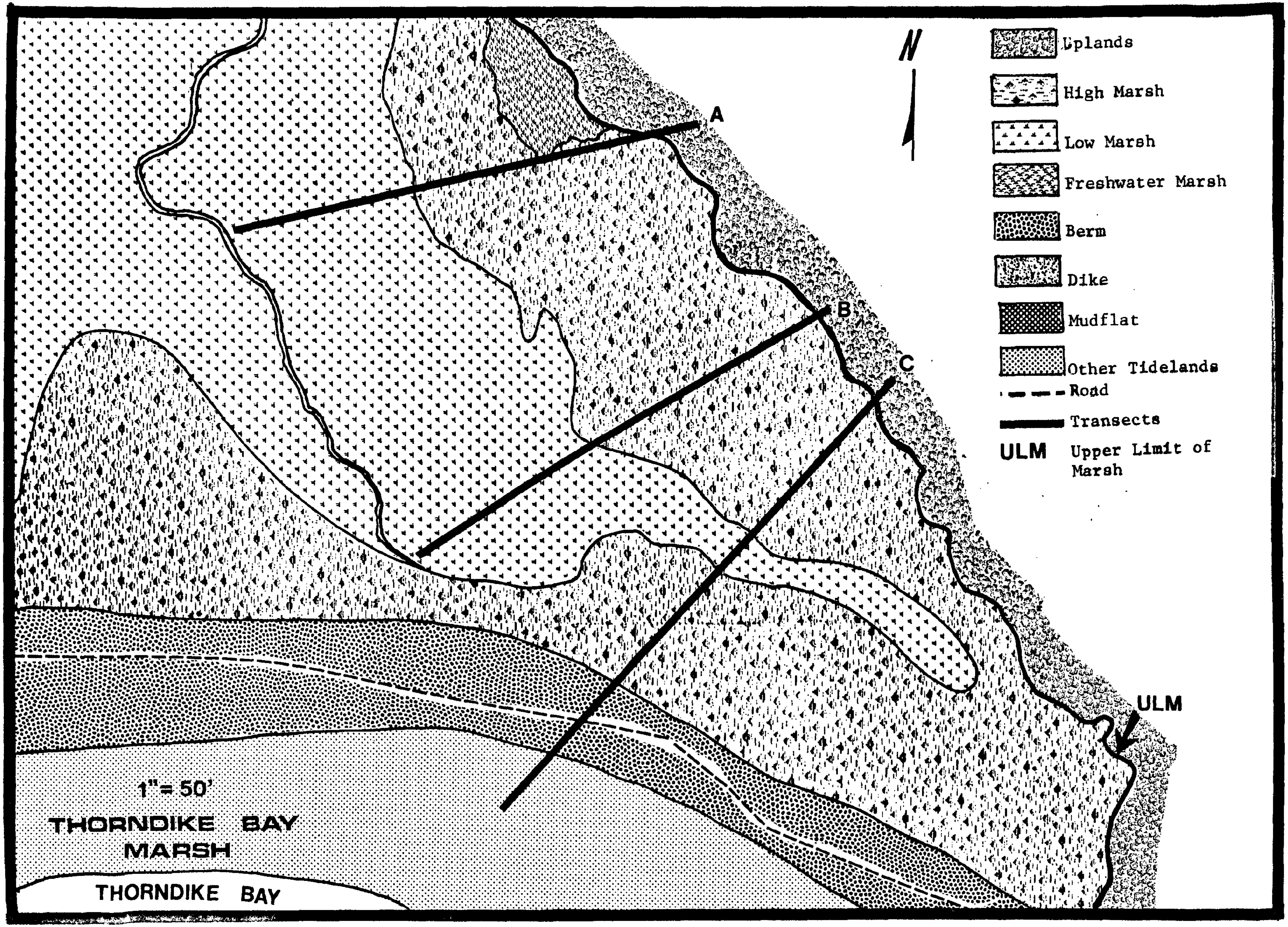
The Thorndike marsh is diverse and contains unusual characteristics. The outer berm with the presence of surf grass *Elymus mollis*, and the marsh with stands of cord grass, *Spartina foliosa*, are reminicent of outer-coast marshes, and not at all common in Puget Sound. Also, co-occuring in the tidal marsh are pockets of freshwater with freshwater flora. Around the perimeter of the marsh there exists an interesting mixture of halophytes, freswater plants, and weedy species introduced when the adjacent uplands were homesteads. The predominant flora are halophytes. The intensity and constancy of the surface groundwater seepage along the margins is thought to be a factor in maintaining the high species diversity found at Thorndike.

Thorndike Bay is used extensively by waterfowl and has been observed to be completely covered with birds. Several of the species are migratory. The off-shore area just outside the barrier berm is leased for commercial harvesting of geoducks. Numerous oysters and clams are found on the tidelands. The productivity of the Thorndike marsh probably contributes a significant portion of the detrital material entering the Hood Canal ecosystem.

If the marsh is not encroached upon by development it should continue as an important component to the coastal marsh network.


THORNDIKE BAY
HOOD CANAL
LOFALL FERRY
South Point
Piles
Light
Thorndyke Lake
Thorndyke Bay
Mud
Gravel
Sand
PIPELINE
WILLAMETTE
Creek
ROAD
N
Light


THORNDIKE BAY


Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM Upper Limit of Marsh
N
A
B
C
ULM
1" = 50'
THORNDIKE BAY MARSH
THORNDIKE BAY

SITE: Thorndike

TRANSECT NUMBER: A

DATE OF SAMPLING: Oct. 15, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT *	
(height to be added when tidal elevations available)	0	Distichlis spicata	B
		Hordeum brachyantherum	B
		Atriplex patula var. hastata	B
		Grindelia integrifolia var. macrophylla	B
		Salicornia virginica	B
		Jaumea carnosa	B
		Juncus gerardii	B
	24	Jaumea carnosa	E
	43	Salicornia virginica	E
	65	Triglochin maritimum	B
		Agrostis alba var. stolonifera	B
	77	Aster sp.	B
		Plantago maritima	B
	87	Potentilla pacifica	B
	82	Grindelia	E
	102	Scirpus acutus	B
		Juncus balticus	B
	119	Juncus gerardii	E
		Epilobium watsonii	B
	121	Atriplex patula var. hastata	E
	146	Rumex occidentalis	+
		Juncus balticus	E
	157	Galium trifidum	+
		Oenanthe sarmentosa	+
	161	Stellaria sp.	+
	163	Juncus effusus	B
	165	Triglochin maritimum	E
	167	Distichlis spicata	E
	168	Scirpus acutus	E
	169	Rosa nutkana	B
	171	Juncus gerardii	E
		Holcus mollis	B
	174	Equisetum telmateia	+
		Lysichitum americanum	B
	177	Potentilla pacifica	E
	181	Marsh Ends (ULM)	
	185	Athyrium filix-femina	B
		Rubus ursinus	B
		Pteridium aquilinum	B
		Agropyron repens	B
		Dactylis glomerata	B
		Polystichum munitum	B
		Lathyrus palustris	B
	188	Juncus effusus	E

* B = Begins, E = Ends
+ = single plant

SITE: Thorndike

TRANSECT NUMBER: B

DATE OF SAMPLING: Oct. 15, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
(height to be added when tidal elevations available)	0 feet	_Agrostis alba_ var. _stolonifera_	B
		Jaumea carnosa	B
		Distichlis spicata	B
		Atriplex patula var. _hastata_	B
		Grindelia integrifolia var. _macrophylla_	B
	20	_Juncus balticus_	B
	41	_Galium trifidum_	+
	47	_Atriplex patula_ var. _hastata_	E
	52	_Potentilla pacifica_	E
	57	_Distichlis spicata_	E
	73	_Scirpus acutus_	B
	75	_Triglochin maritimum_	B
	79	_Holcus mollis_	B
	84	_Juncus balticus_	E
		Juncus effusus	B
		Epilobium watsonii	B
		Mentha arvensis	+
	90	_Rosa nutkana_	B
	92	_Scirpus acutus_	E
	95	_Potentilla pacifica_	E
		Geum macrophyllum	+
	97	_Carex lyngbyei_	B
		Athyrium filix-femina	B
	99	_Rubus ursinus_	B
		Juncus ensifolius	B
		Prunella vulgaris	B
	103	_Carex lyngbyei_	E
		Marsh ends (ULM)	
	108	_Juncus effusus_	E
		Dactylis glomerata	B
		Lathyrus palustris	B

* B = Begins, E = Ends   + = single plant

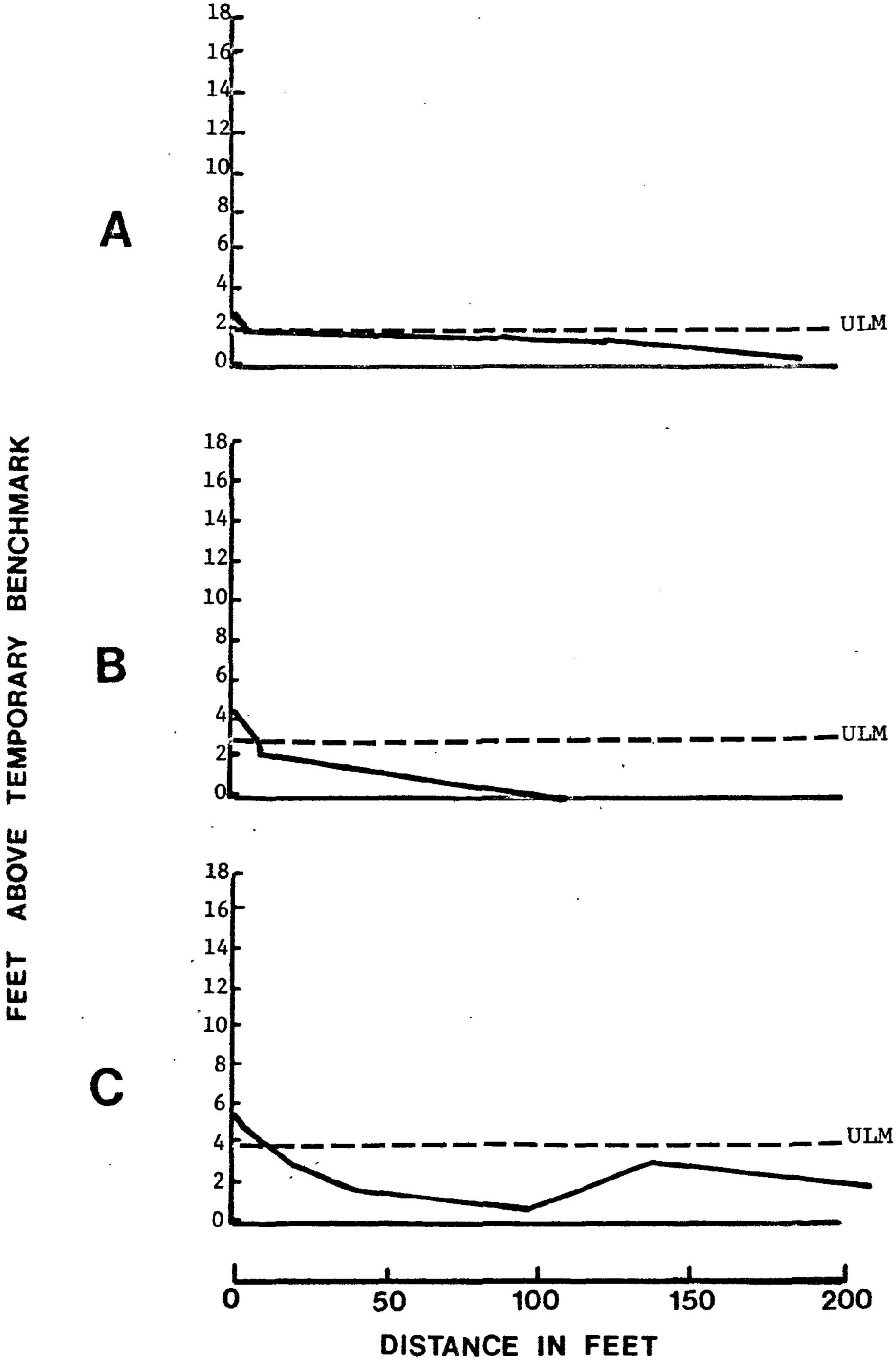
SITE: Thorndike

TRANSECT NUMBER: C

DATE OF SAMPLING: Oct. 15, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT *	
(height to be added when tidal elevations available)	0 feet	Ambrosia chamissonis var. bipinnatisecta	B
		Grindelia integrifolia var. macrophylla	B
		Plantago Lanceolata	B
		Achillea millefolium var. californica	
		Festuca rubra	B
	3	Elymus mollis	B
	12	Elymus mollis	E
	14	Rumex acetosella	B
	26	Polygonum cf. spergulariaeforme	B
	44	Bromus mollis	B
	48	Polygonum cf. spergulariaeforme	E
	51.5	Rumex occidentalis	B
	66	All Above Except Grindelia	E
		Salicornia virginica	B
		Distichlis spicata	B
		Juncus gerardii	B
		Atriplex patula var. hastata	B
	72	Hordeum jubatum	B
	79	Jaumea carnosa	B
	106	Grindelia integrifolia var. macrophylla	E
		Jaumea carnosa	E
		Salicornia virginica	E
		Juncus gerardii	E
		Agrostis alba	B
	115	Juncus balticus	B
	129	Plantago maritima	B
	134	Potentilla pacifica	B
	148	Aster sp.	B
	154	Plantago lanceolata	B
	160	Achillea millefolium var. californica	B
	169	Plantago maritima	E
	171	Epilobium watsonii	+
	174	Juncus effusus	B
		Juncus balticus	E
		Agrostis alba	E
		Aster sp.	E
		Alnus rubra	B
	178	Rosa nutkana	B
		Cirsium arvense	B
		Potentilla pacifica	E
	181	Rubus ursinus	B
		Pteridium aquilinum	B
	185	Equisetum telmateia	B
	187	Athyrium filix-femina	B
	191	Carex lyngbyei	+
	193	Polystichum munitum	+
	197	Holcus mollis	B
		Dactylis glomerata	B
	199	Marsh Ends (ULM)	
	210	Juncus effusus	E
		Equisetum telmateia	E
		Lathyrus palustris	B

* B=Begins, E=Ends
+ = single plant



THORNDIKE BAY

LOCATION OF TRBM

TBM #1 - is a 1" iron pipe meander of 19/24, 6' north of white 2 x 4 marker 1 foot south of center line dirt road on berm.

TBM #2 - is two 1" iron pipe 1.25 feet high 60' east of meander corner triangulation point.

2.11 ft. = TBM #2 - TBM #1

-1.94 ft. = TBM #1 - ULM (A transect)

-0.66 ft. = TBM #1 - ULM (B transect)

-0.16 ft. = TBM #1 - ULM (C transect)

Position of ULM on profiles relative to TBM

ULM ELEVATIONS

Thorndike

5.70 ft.
4.42 "
3.60 "
3.70 "
3.55 "
3.21 "
3.58 "
5.25 "
4.45 "
5.35 "
4.15 "
4.0 "
5.8 "
5.62 "
5.6 "
4.8 "
5.2 "

$\bar{X}$ = 4.59 *
S = 0.89

Normalized to 0 in text.

GROUNDWATER MOVEMENT DATA

Site: Thorndike

Date of Sampling: October 15, 1976

Height of Tide:

Height of MHHW:

Salinity of Thorndike Bay Waters: 20.5 $^{o}/oo$

TIME:	11:12	12:12	TOTAL CHANGE	$T^{o}C$	S $^{o}/oo$	LOCATION:
CHANGE	0	0	0	10.5	0	T* **A****
IN CM	0	+1.5	+1.5	10.5	0	T + 1'

	11:12	12:12	TOTAL CHANGE	$T^{o}C$	S $^{o}/oo$	
CHANGE	0	-2.1	-2.1	11.5	0	T **B**
IN CM	0	0	0	12.5	0	T + 1'

	11:12	12:12	TOTAL CHANGE	$T^{o}C$	S $^{o}/oo$	
CHANGE	0	+1.5	+1.5	17.5	0	T **C**
IN CM	0	0	0	--	--	T + 1'

* T = Transition
** Transect

COMMUNITY COMPOSITION

THORNDIKE
October 15, 1976

SPECIES	REPLICATES					
	I	II	III	IV	V	VI
Juncus balticus	5*	5	5	5	5	3
Triglochin maritimum	2	1	1	1		
Potentilla pacifica	2	2		2	1	1
Plantago lanceolata	1					
Agrostis alba	1	1	1			
Distichlis spicata			1		1	1
Aster sp.					2	
Vicia gigantea					1	1
Scirpus acutus						2
Oenanthe sarmentosa						1
Mentha arvense						1
Galium trifidum						1

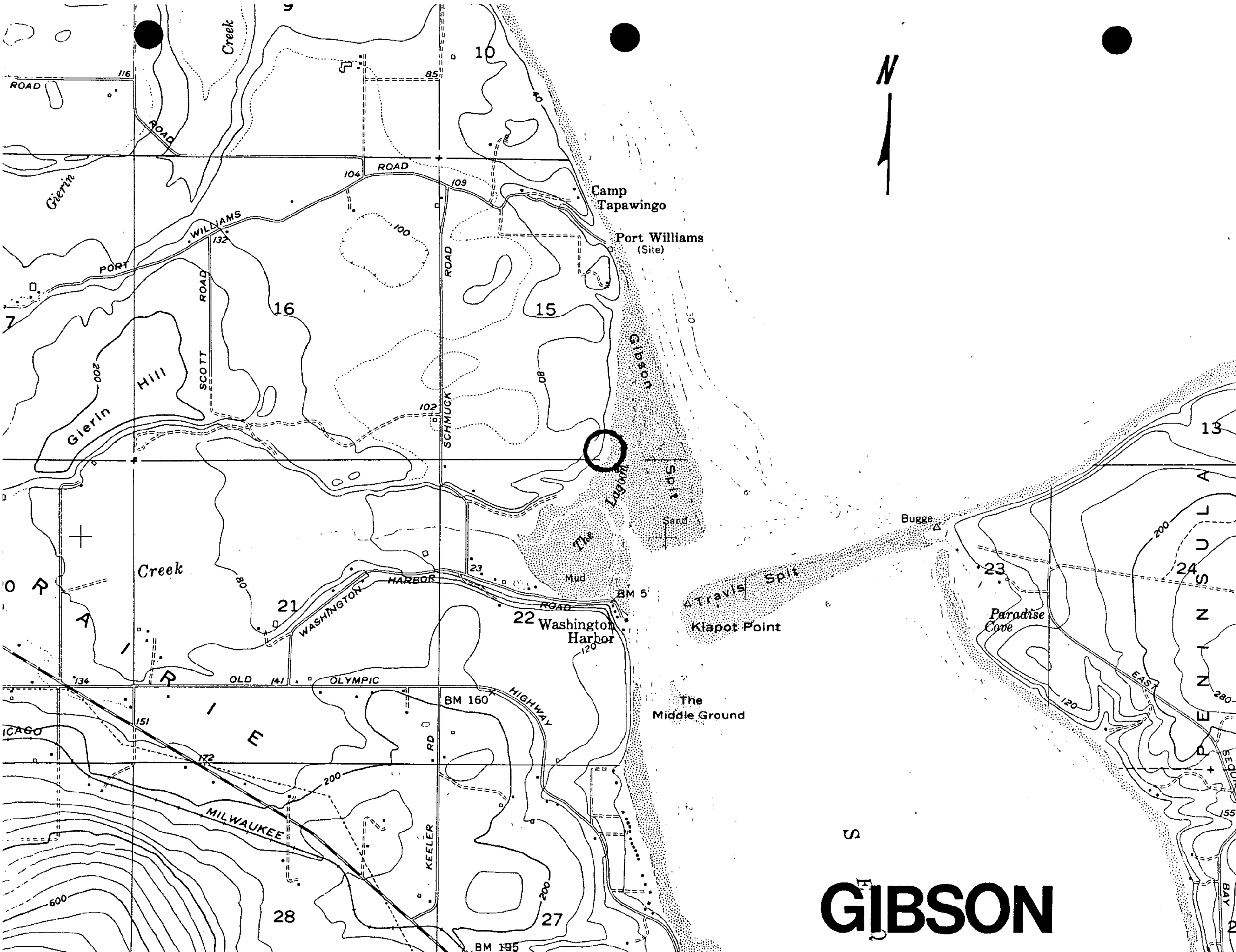
*Numbers correspond to percent coverage classification. See Table 1, *Methods and Materials*.

GIBSON

GIBSON MARSH

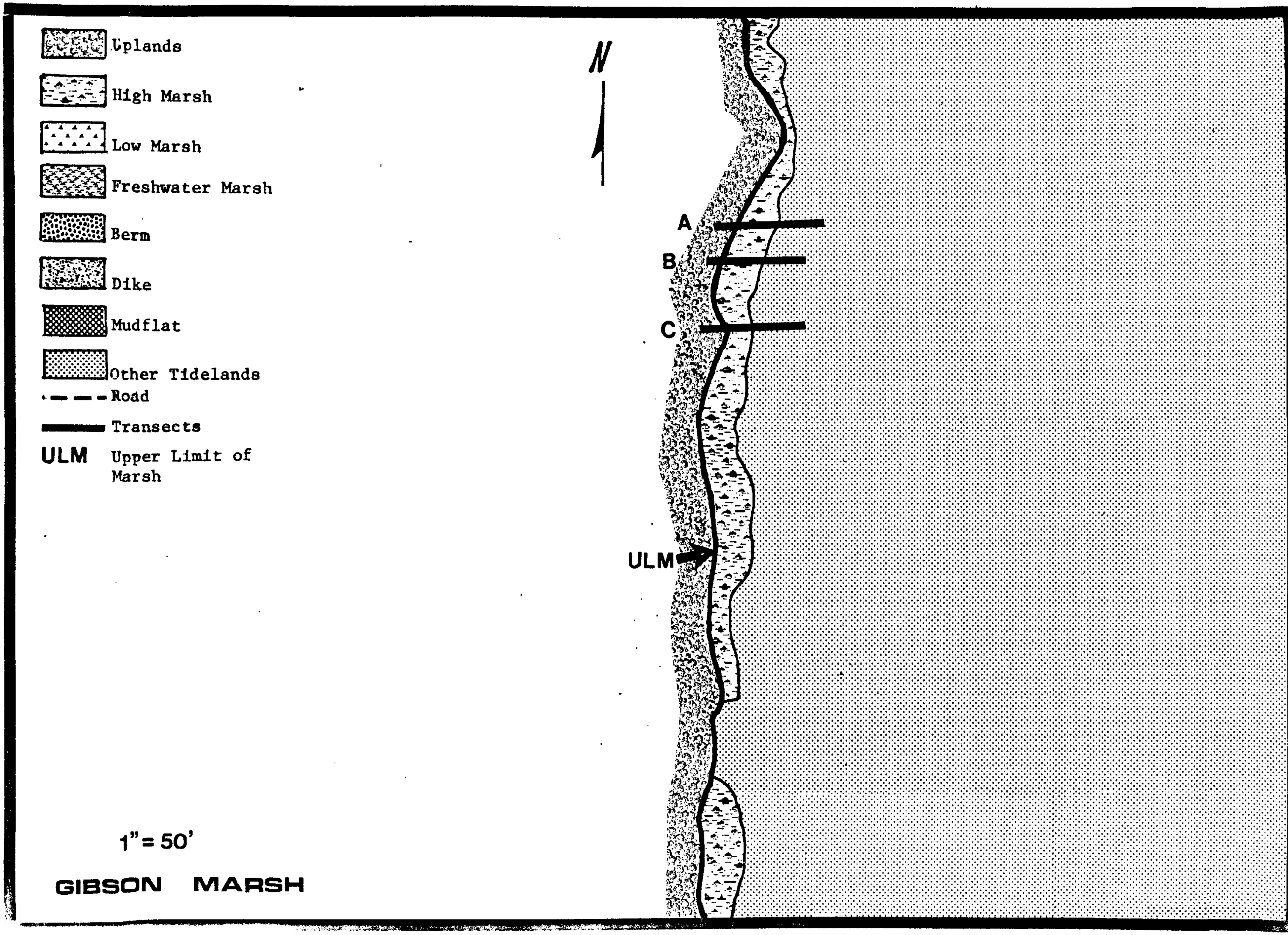
This marsh is a three part embayment with its outer berm facing Protection Island. The berm protects the inner bays from Strait of Juan de Fuca waves. Gibson marsh connects with Sequim Bay. Historically, it was one bay, but two dikes now dissect the bay. The northern-most inner dike prevents embayed water from contact with the other two bays. As such it has converted to a freshwater marsh from incursion of groundwater. However, with the lack of rain in the fall of 1976 the marsh was drying up. The other two bays are connected by two 5 foot diameter culverts which allow for a free exchange of sea water with the transition area. The currents are strong as indicated by the presence of Nereocysitis luetkeana and a cobble, shell bottom.

Except for an incoming stream area with heavy domestic farm animal grazing,the transiton is along a high bank, with numerous boulder outcroppings. Some evidence of fresh groundwater at or above the ULM was noted by the presence of Equisetum telmateia. The predominant salt creek ran parallel to the transition such that the majority of the marsh area/was covered by Salicornia virginica, Distichlis spicata, Elymus mollis, Grindelia integrifolia var. macrophylla which were on the flats lying between the channel and outer beach.


N
Camp Tapawingo
Port Williams (Site)
Gibson Spit
The Lagoon
Sand
Mud
Travis Spit
Klapot Point
The Middle Ground
Bugge
Paradise Cove
Washington Harbor
PORT WILLIAMS ROAD
SCHMUCK ROAD
SCOTT ROAD
WASHINGTON HARBOR ROAD
OLD OLYMPIC HIGHWAY
KEELER RD
MILWAUKEE
Gierin Hill
Gierin Creek
PRAIRIE
PENINSULA
EAST SEQUIM BAY
BM 5
BM 160
BM 195

GIBSON


GIBSON MARSH



Uplands
High Marsh
Low Marsh
Freshwater Marsh
Berm
Dike
Mudflat
Other Tidelands
Road
Transects
ULM Upper Limit of Marsh
N
A
B
C
ULM
1" = 50'
GIBSON MARSH

SITE: GIBSON

TRANSECT NUMBER: A

DATE OF SAMPLING: NOVEMBER 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
(height to be added when tidal elevations available)	0	_Carex lyngbyei_	B
		Fucus distichus	
	7	_Fucus distichus_	E
	16		
	19	_Carex lyngbyei_	E
		Distichlis spicata	B
	20	_Distichlis spicata_	E
	21	Upper limit of marsh	(ULM)
	22	_Juncus_ sp. (vegetative)	B
	23	_Equisetum telmateia_	B
		Ribes sp. (vegetative)	B
	26	_Rosa nutkana_	B

* B = Begins, E = Ends

SITE: GIBSON

TRANSECT NUMBER: B

DATE OF SAMPLING: NOVEMBER 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
(height to be added when tidal elevations available)	0	Carex lyngbyei	B
		Enteromorpha sp.	
	1	Enteromorpha sp.	E
	17	Carex lyngbyei	E
		1-ft. high ledge	
	18		
		Triglochin maritimum	B
		Distichlis spicata	B
	20	Distichlis spicata	E
		Galium aparine	B
		Hordeum brachyantherum	B
	21.5	Equisetum telmateia	B
	23.5	(ULM)	
	24	Agrostis alba va. stolonifera	B
	28		
		Rosa nutkana	B

* B = Begins, E = Ends

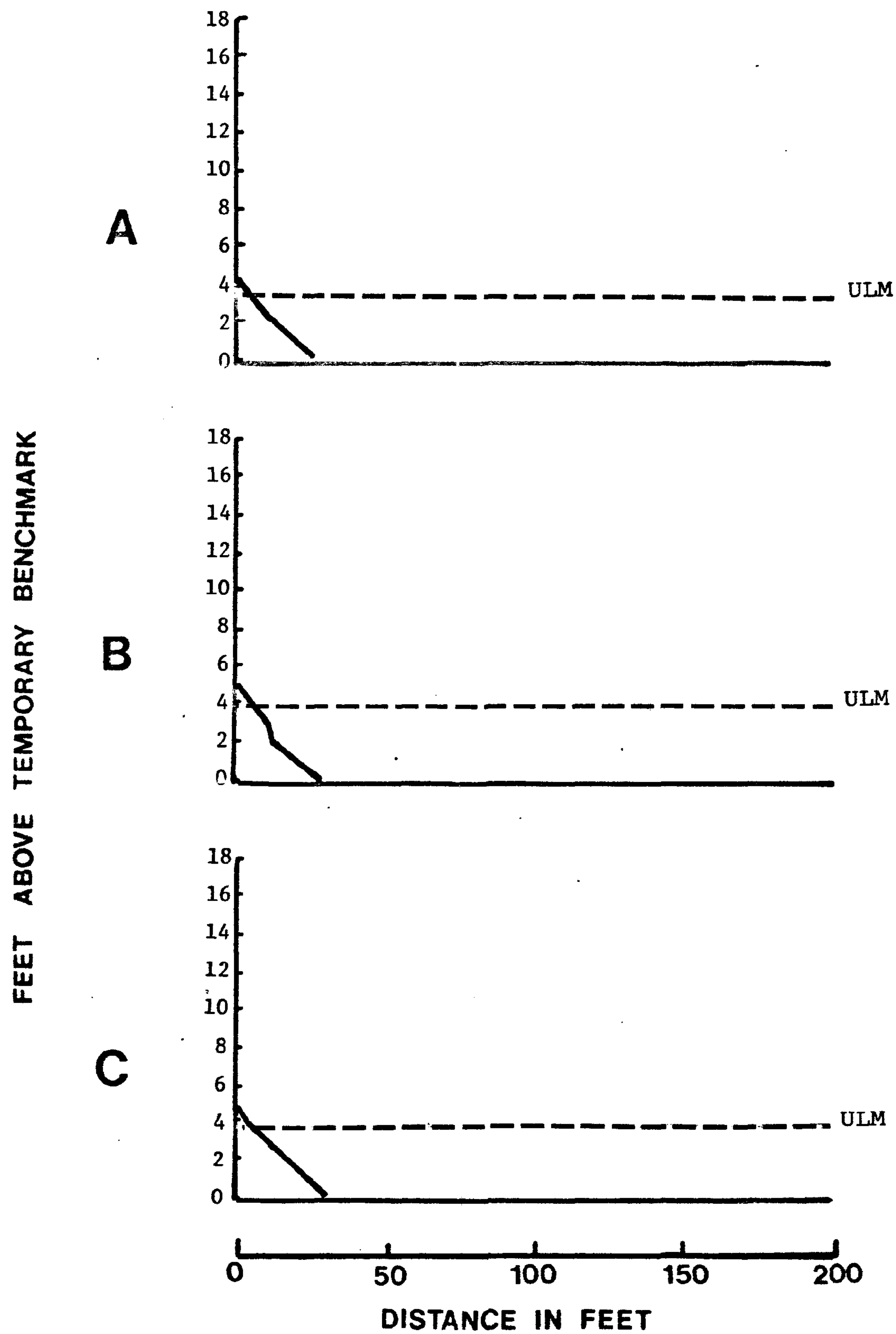
SITE: GIBSON

TRANSECT NUMBER: C

DATE OF SAMPLING: NOVEMBER 9, 1976

TIDAL HEIGHT ABOVE MLLW	DISTANCE FROM STARTING POINT	EVENT*	
(height to be added when tidal elevations available)	0	Carex lyngbyei	B
		Enteromorpha sp.	
		Fucus distichus	
		Gigartina papillata	
	1	Fucus distichus	E
		Gigartina papillata	E
	14	Enteromorpha sp.	E
	19	Carex lyngbyei	E
		Poa sp. (vegetative)	B
	19.5		
	23	Agrostis alba	B
	24	Poa sp.	E
	26	(ULM)	
	27	Equisetum telmateia	B
		Epilobium cf. watsonii	B
	29.5	Urtica dioica	B
		Galium aparine	B
	30		
		Rosa nutkana	B
		Ribes cf. divaricatum	B

* B = Begins, E = Ends

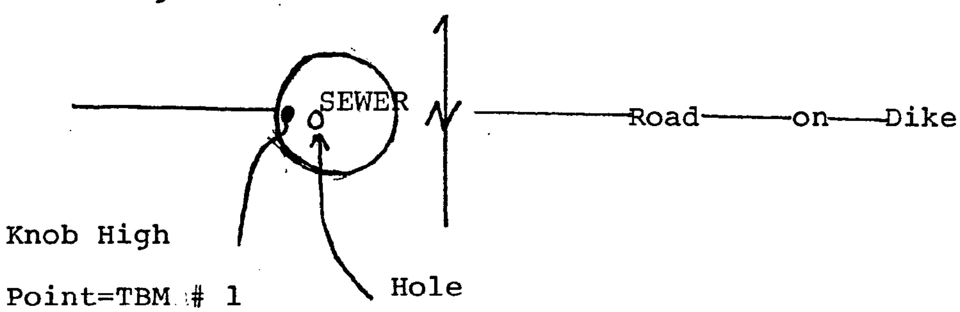


GIBSON MARSH

LOCATION OF TRBM

Bench mark is a brass cap on northwest corner of structure 7' x 4.5' - 2.5' high. Cap stamped $\frac{\text{"5"}}{1944}$ but has been placed recently. Identification as "Battelle #5" tentative.

TBM #1 In road on sewer dike. Approximately 200 feet east of gate.



TBM # 1 = 3.69 below "Battelle # 5"

3.80 ft. = TMB #1 - ULM (A Transect)

3.10 ft. = TMB #1 - ULM (B Transect)

3.50 ft. = TMB #1 - ULM (C Transect)

ULM ELEVATIONS

Gibson

4.80 ft.
4.10 "
4.50 "
5.00 "
3.30 "
4.10 "
5.00 "
5.00 "
4.80 "

$\bar{X}$ = 4.51 *
S = 0.58

Normalized to 0 in text.

GROUNDWATER MOVEMENT DATA

SITE: Gibson

DATE OF SAMPLING: November 8, 1976

Height of Tide: 7 feet

Height of MHHW:

Salinity of Gibson Bay waters: $26^{o}/oo$ - $27^{o}/oo$

TIME:	14:30	15:40	TOTAL CHANGE	T°C	S °/oo	LOCATION:
CHANGE IN CM	Flooded	Flooded	N/A	10	2.5	T* + 1'
	Flooded	Flooded	N/A	10	2.8	T A**

	14:30	15:40	TOTAL CHANGE	T°C	S °/oo	
CHANGE IN CM	Flooded	Flooded	N/A	10	2.8	T + 1'
	Flooded	Flooded	N/A	10	2.0	T B

	14:30	15:40	TOTAL CHANGE	T°C	S °/oo	
CHANGE IN CM	Flooded	Flooded	N/A	10	2.5	T + 1'
	Flooded	Flooded	N/A	10	2.0	T C

* T = Transition
** Transect

COMMUNITY COMPOSITION

GIBSON
November 9, 1976

SPECIES	REPLICATES I	II	III	IV	V	VI
Juncus sp.	3*	3				
Poa sp.	4				1	
Agrostis alba		1	2			
Equisetum telmateia		1	1	1		
Carex lyngbyei		2	2	5	3	6
Galium trifidum			1			
Triglochin maritimum			2	1	2	1
Hordeum brachyantherum					1	

*Numbers correspond to percent coverage classification. See Table 1 , *Methods and Materials*.

APPENDIX II

AQUATIC LANDS PLANT SPECIES LIST

AQUATIC LANDS

PLANT SPECIES LIST *

SPECIES	ZONE **	COMMON NAMES
Acer macrophyllum	UL	Maple
Achillea millefolium var. californica	UL	Yarrow
Agropyron repens	TS, SM	Wheatgrass
Agrostis alba var. palustris	TS, SM	Bentgrass
Agrostis alba var. stolonifera	TS, SM	"
Alnus rubra	FM, UL	Red alnus
Ambrosia chamissonis var. bipinnatisecta	SM	Bursage
Anaphalis margaritacea	UL	Pearly-everlasting
Arbutus menziesii	UL	Madrone
Armeria maritima var. californica	SM	Sea pink
Aster sp.	TS, UL	Aster
Athyrium filix-femina	TS, UL	Lady-fern
Atriplex patula var. hastata	TS, SM	Saltbush
Bromus mollis	UL	Soft cheese
Carex lyngbyei	UL, TS,	Sedge
Cichorium intybus	UL	Chicory
Cirsium arvense	UL	Thistle
Cirsium vulgare	UL	"
Convolvulus sepium	UL	Morning glory
Crataegus douglasii var. suksdorfii	UL	Hawthorn
Cuscuta salina	SM	Dodder
Cytisus scoparius	UL	Scotch broom
Dactylis glomerata	UL	Orchard grass
Distichlis spicata	SM	Salt grass
Elymus mollis	SM	Surf grass
Enteromorpha sp.	Subtidal	Intestine shape
Epilobium watsonii	UL, FM,	Willow-weed
Equisetum arvense	UL	Horsetail
Equisetum telmateia	UL	Horsetail
Festuca rubra	UL, TS	Red fescue
Fucus distichus	Subtidal	Rock weed
Galium aparine	UL	Bedstraw
Galium trifidum	SM	"
Geum macrophyllum	TS, UL	Avens
Gigartina papillata	Subtidal	Grapestone
Grindelia integrifolia var. macrophylla	TS, SM	Gum weed
Holcus mollis	UL	Creeping Velvet Grass
Holodiscus discolor	UL	Ocean-spray
Hordeum brachyantherum	SM	Meadow barley
Hordeum jubatum	SM	Foxtail barley

* Nomenclature follows Hitchcock and Cronquist, 1974

** UL = Upland
TS = Transition saltmarsh
SM = Saltmarsh
FM = Freshwater marsh
TF = Transition Freshwater marsh
TZ = Transition zone (TS + TF)

SPECIES	ZONE	COMMON NAMES
Impatiens noli-tangere	FM	Touch-me-not
Jaumea carnosa	SM	Jaumea
Juncus balticus	SM	Rush
Juncus effusus	UL, TS	"
Juncus ensifolius	TS	"
Juncus gerardii	SM	"
Lathyrus palustris	TS, UL	Marsh pravine
Lilaeopsis occidentalis	FM	Western lilaeopsis
Lonicera involucrata	UL	Honeysuckle
Lotus corniculatus	TF	Pea
Lycopus americanus	FM	Northern bugleweed
Lysichitum americanum	FM	Skunk cabbage
Mentha arvensis	FM	Mint
Myrica gale	UL	Sweet gale
Myriophyllum cf. spicatum	FM	Water milfoil
Oenanthe sarmentosa	SM	Water parsley
Osmaronia cerasiformis	UL	Evening primrose
Phalaris arundinacea	UL	Indian plum
Plantago lanceolata	UL	Reed canary grass
Plantago maritima	SM	Water plantain
Poa sp.	SM	Blue grass
Polygonum cf. spergulariaeforme	SM	Sperry knotweed
Polygonum fowleri	SM	Fowler's knotweed
Polystichum munitum	UL	Sword fern
Potentilla pacifica	TF, TS	Silver weed
Prunella vulgaris	UL	Pacific self-heel
Pseudotsuga menziesii	UL	Douglas fir
Pteridium aquilinum	UL	Bracken fern
Pyrus fusca	UL	Western crabapple
Pyrus malus	UL	Apple
Ribes cf. divaricatum	UL	Goose berry
Ribes spp.	UL	" "
Rorippa islandica	FM	Marsh yellowcress
Rosa nutkana	UL	Nootka rose
Rubus discolor	TZ, UL	Himaleyan blackberry
Rubus laciniatus	TZ, UL	Evergreen blackberry
Rubus spectabilis	TZ, UL	Salmonberry
Rubus ursinus	TZ, UL	Pacific blackberry
Rumex acetosella	UL	Sour weed
Rumex occidentalis	SM	Western dock
Salicornia virginica	SM	Pickleweed
Salix spp.	TZ, UL	Willow
Scirpus acutus	SM, FM	Bulrush
Solanum dulcamara	UL	Blue bindweed
Solidago canadensis	UL	Goldenrod
Sonchus arvensis	UL	Field milk-thistle
Spergularia canadensis	SM	Sand spurry
Spergularia macrotheca	UL	" "
Spergularia marina	UL	" "
Spiraea douglasii	UL	Douglas spirea
Stellaria sp.	SM	Star wort
Symphoricarpos albus var. laevigatus	UL	Snow berry
Taraxacum officinale	UL	Dandelion

SPECIES	ZONE	COMMON NAMES
Triglochin maritimum	SM	Arrow-grass
Typha latifolia	TF	Cattail
Urtica dioica	UL	Nettle
Vicia gigantea	TF	Giant vetch
Vinca major	UL	Periwinkle