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(IN Prep.)

2200

MACROPHYTIC VEGETATION
OF THE FRESHWATER KETTLE PONDS
OF CAPE COD NATIONAL SEASHORE

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INTRODUCTION

The Cape Cod National Seashore encompasses twenty freshwater kettle ponds which currently exhibit a series of trophic states ranging from near-pristine oligotrophy (e.g. Duck, Dyer) to extreme eutrophy (e.g. Williams, Turtle). The potential for acceleration of natural succession phenomena within these ponds due to increased recreational use has generated much concern and initiated a reassessment of management policy (see Soukup 1977).

Macrophytic pond vegetation is of primary interest to the Park Service management in two respects. First, the pond flora at any time should provide a rough indication of the trophic state of the community. The dominant vegetative characters of a pond community will evolve and change as the pond undergoes successional change. And due to the unique ecological niche requirements of each plant species, the plant community at any ^{physical} point in this temporal sequence of pond succession (as over a spatial environmental gradient) should exhibit a uniquely characteristic assemblage of species.

Secondly, and perhaps more urgently, macrophytic vegetation within and around the ponds often interferes with recreational use and enjoyment of the pond resources. Thick mats of lilies and pondweeds can hinder swimming, boating and fishing while heavy growth of emergent sedge and rushes can compete with bathers for prime beach space.

However, management policy concerning pond vegetation should be a basic understanding based upon the composition and extent of the present plant community as well as present trends in species competition. The primary purpose of this summer field study was therefore to conduct inventory of the plants growing within and bordering the kettle ponds, while collecting material for a reference herbarium collection of the flora. In addition, preliminary rough maps were sketched indicating potential problem sites of dense macrophytic growth. While past National Park Service reports have commented on pond plant life, including those by Hinds (1966), Godfrey (1976), Randal (1976), and Soukup (1977), none have attempted an exhaustive inventory and mapping.

METHODS

Field data were collected from seventeen of the twenty freshwater kettle ponds within the boundaries of Cape Cod National Seashore, in Wellfleet and Truro, Massachusetts during the summer of 1978 (June 22 to August 27). Vegetation sampling was qualitative -- wading and occasionally canoeing around the pond periphery, and carefully collecting and sampling at randomly chosen sites. Bottom growth sampling in some ponds was aided with a rake (up to 4 m depth) and with a line and grappling hook beyond that depth.

In order to effectively and accurately map the extent of macrophytic vegetation in and around the ponds as originally planned, accurate maps of the ponds themselves are needed. With the exception of Duck Pond, these are lacking. The extent of mapping achievable was roughly to sketch vegetation as observed in the field onto outline maps of the ponds traced from aerial photos (Data scale: 1" = 200') found in the Marconi Station library.

A complicating factor encountered was the phenomenon of a drawn out flowering season that started in late June and apparently extended well beyond the end of my study period in August. Moreover, most species of pond vegetation were not identifiable to species in immature forms and many required fruit as the identifying characteristic.

To properly investigate the plants of a pond truly necessitates regular surveys on a weekly basis over the whole summer and into the fall, which was not possible. Compiling the reference collection became a primary goal as the study proposed. The geographical scope of the project was reduced to to equipment and time restraints by neglecting the northernmost ponds in Truro (Round (W), Ryder, Great (T)). In addition, two privately-owned ponds with restricted access (Kinnacum, Round (E)) were eliminated from study. Focus was thus on seven ponds: Gull, Higgins, Williams, Herring, Slough, Duck, and Spectacle (although a total of seventeen were visited over the summer). Of these seven, the readily accessible Gull, Higgins, Williams, and

Herring received the most attention. The mounting and labeling of the collection and the compilation of data and ultimate writing of this final report were completed after the summer ended. Limnological data were taken according to (Strickland and Parsons 1972).

RESULTS

Herbarium Collection. The primary product of this work, the reference collection representing approximately 90 species has been completed.

Table II lists those species encountered within and around the ponds. A few are not included in the collection itself. In some cases the decision of what to include in the collection of border shrub was arbitrary at best. The plants were identified using keys in the following texts:

Fernald, M.L., Gray's Manual of Botany, 8th ed., N.Y.,
D. Van Nostrand Company, 1950.

Fassett, N.C., Manual of Aquatic Plants, University of
Wisconsin Press, 1957.

Prescott, G.W., Algae of the Western Great Lakes,
Dubuque, Wm. C. Brown Company, 1951.

The three species of moss dredged from the bottom of Duck Pond (at 14m depth) were identified by Prof. Norton Miller (Harvard University.)

Table III records in tabular form the occurrence of plant species in individual ponds. However, because of the aforementioned limitations

in sampling, the lack of an "X" cannot invariably be interpreted as a lack of presence, except in the more thoroughly investigated ponds.

Table IV gives Chlorophyl a and Specific Conductivity values for all kettle ponds.

Appendix 3 presents the rough, field-sketched maps (in a slightly refined form) of vegetation in specific ponds, and is primarily intended to help locate sites noted in the following discussion.

DISCUSSION

The pond vegetation is best evaluated by subdividing the set into habitat groups. The four subsets that best represent field observations are (1) true aquatics, (2) sublittoral emergents, (3) eulittoral emergents, and (4) border shrub. "Primary species"¹ are those dominant in the habitat community, and thus those potentially posing management problems in some Cape Cod ponds. "Secondary species" encompass the remaining portion of the flora.

True Aquatic Species include wholly submerged and floating-leaved species of the sublittoral and infralittoral zones.²

¹ For simplification, only generic names are listed whenever possible. To check specific names, consult the complete list in Table II

² The eulittoral zone is the harsh shoreline zone of fluctuating water levels.

Primary Species

Nuphar
Nymphaea
Brassenia

Myriophyllum
Utricularia purpurea
U. vulgaris

Secondary Species

Sphagnum
Diepanocladus
Chara
Nitella

Najas
Elodea
Nymphoides
Potamogeton

Sublittoral Emergent Species are those truly hydrophilic species rooted in the sublittoral and littoral zones, but appearing emergent at maturity:

Primary Species

Pontedaria
Juncus militaris
Nymphaea

Decodon
Lobellia

Secondary Species

Sphagnum
Sagittaria
Eleocharis Robbinsii
E. acicularis
E. obtusa

E. parvula
Scirpus subterminalis
Eriocaulon
Hypericum boreale

Eulittoral Emergent Species. This largest category of plants encompasses all those species found along the moist and frequently flooded shoreline of the ponds. They are characteristic of marsh and bog environments

The sublittoral zone is the adjacent region of shallow but constant water levels, and extends to the limiting depth of growth of large benthic plant species.

The infralittoral zone is a deeper region extending from the sublittoral down to the lower limit of photosynthesis. (fide. Polunin, 1960)

and frequently grow on a mat of Sphagnum moss. Many are simply hardy terrestrial species that range in drier habitats as well:

Primary Species

Sphagnum

Scirpus americanus

Secondary Species

Typha
Calamagrostis
Spartina
Scirpus cyperinus
Cyperus
Eleocharis palustris
E. ambigens
Carex
Cladium
Xyris
Juncus effusus
J. canadensis
J. secundus
J. pelocarpus
Iris
Rumex
Drosera
Spiraea

Hypericum virginicum
H. canadense
Viola
Rhexia
Hydrocotyle
Lysimachia
Asclepias
Lycopus
Cicuta
Sium
Gratiola
Gerardia
Utricularia gibba
Galium
Solidago
Eupatorium
Coreopsis

Border Shrub Species. A distinct community of mesic shrubs and small trees, many of which are ericaceous or ericoid in character. Some species (e.g. Chamaedaphne, Vaccinium macrocarpon) characteristically venture far into the water. In fact, Chamaedaphne is a pioneer species prerequisite to the formation and development of bog mats (Swan & Gill, 1970). Other species, however, are more strictly limited to drier border areas:

Primary Species

Myrica
Rhus

Clethra
Chamaedaphne

Secondary Species

Pinus
Populus
Betula
Alnus
Quercus
Rosa
Pyrus
Robinia

Ilex
Acer
Hibiscus
Rhododendron
Kalmia
Lyonia
Vaccinium
Viburnum

The distribution of these floral elements among the ponds reflects their estimated trophic status.

Duck, Dyer, and ~~Cherry~~ Ponds, which spring levels of chlorophyll a indicate to be obligotrophic, were found to be deficient in numerous species of pond weeds growing in other more productive ponds. Even the most ubiquitous species encountered during the study: aquatics Potamogeton (four species), Nuphar, Nymphaea and Nymphoides, and emergents Eleocharis (four species), Scirpus (three species), and Decodon were glaringly lacking in these three ponds. Characteristic of the oligotrophic ponds were simply Lobelia dortmanna and Juncus militaris (except Duck).

On the other hand, one pond indicated by Soukup (1977) to be eutrophic, Williams, supports a rich and diverse aquatic flora. Data from this study suggest, as well, that certainly Turtle and possibly Herring Ponds are eutrophic. The flora in these three shallow ponds exhibits many similarities. All three contain dense regions of floating aquatics such as Myriophyllum and Utricularia, as well as healthy lily communities of Nuphar and Nymphaea. Interestingly, Lobelia dortmanna is absent only in these ponds.

Based upon these floral indicators, the rest of the Cape Cod kettle ponds fall within a continuum of trophic states between the two above extremes. For these intermediate mesotrophic ponds, simple presence or absence of a plant species may not be so significant as quantitative community composition data that was not collected. We suggest that the larger ponds: Gull, Slough, Horseleach, and Long are mesotrophic on the oligotrophic end of the scale, while smaller ponds: Higgins, Northeast, Southeast, and Snow remain genuinely mesotrophic. Spectacle Pond, subdivided into two pools, straddles the spectrum: the larger southern pool is closer to oligotrophy, while the small, boggy northern portion is near eutrophic. Similarly, in large ponds having smaller corners or inlets that are beyond the reaches of general pond circulation patterns (e.g. Slough, Higgins, Herring), those corner pockets are choked with uncharacteristically dense pondweed growth.

Higgins and Gull Ponds are both heavily used during the summer season and both exhibit higher plant productivity than their size suggests they should. Dyer, on the other hand, is one of the least used ponds (access roads are closed to automobile traffic), and it supports a sparse, species-deficient flora. Relative to other ponds its size, it is beautifully clear, and unproductive.

These observations indicate that pond vegetation responds to "cultural eutrophication." Indeed, in all the ponds (most visibly the less productive ones -- see Appendix 3) the concentration of rush and sedge growth near beaches and inhabited cottages, and the growth of

lilies in the nearby shallows suggest that aquatic vegetation may be useful as an indicator of excessive nutrient input at point locations. Such implications are worthy of further investigation.

The freshwater ponds of Cape Cod National Seashore are valuable both as natural and recreational resources, and clearly any successful management policy must insure the former while accomodating the latter only to the extent compatible. Pond vegetation is relevant to both. In some cases plant growth may complicate or threaten to interfere with recreational activities such as bathing and boating and therefore becomes a management issue. In other instances, particular plant species are unique or unusual and should be a management concern.

The more densely hatched regions of the maps in Appendix 3 -- particularly those areas out a bit from the shorelines -- indicate particular sites where pondweed growth may indeed present problems. However, while the seasonal period of maximum plant biomass often coincides with midsummer flowering periods, it can also vary up to a month from year-to-year (Westlake, 1974). And furthermore, some pondweed species die down seasonally (e.g. Potamogeton natans) and others occasionally do so (e.g. Myriophyllum sp.), so these hatched regions of the maps are most likely somewhat plastic in shape and size (Westlake, 1974). The best method of monitoring the vegetation density over time would be to establish permanent or else very precisely located quadrat sites (surveyed in relation to prominent landscape features) which could be periodically sampled and photographed (Phillips, 1959).

The following specific sites are worthy of such monitoring: Gull Pond. Two substantial patches of pond lily (Nymphaea odorata) flank either side of the public beach on the pond's southwest shore, from about five to ten m out from the edge, in one to two m of water. The long wiry petioles of the floating Nymphaea leaves could entangle swimmers or boat oars and paddles.

Higgins Pond. Except at frequented sandy beaches, the entire periphery of this pond is heavily vegetated in zones by a rich diverse flora of marsh and bog plants. In addition, the northwest corner inlet is densely clogged with aquatic weeds, but unless the inhabitants of the nearby cottage complain, this congestion should present no overall management problem. The center of Higgins Pond is still open for boating.

Williams Pond is beyond the point of being a recreational pond: the water is too shallow and murky for swimming; the floating areas of lilies (Nymphaea and Nuphar) and narrow-leaved aquatics Utricularia and Myriophyllum are enough to discourage all but the most curious exploring sailors. The whole pond flora should be monitored to note rate of encroachment while a management policy is developed.

Turtle Pond is a case similar to Williams, too eutrophic to currently offer much recreational [✓]value other than fishing.

Herring Pond. The accessible boat-launching beach on the west side of this pond is possibly being encroached upon by growth of a large

flanking patch of Nymphaea and water-shield (Brassenia schreberi).

In addition, the southeast corner and northeast nook are clogged with patches of lily and water-shield, and slightly submerged Myriophyllum and Utricularia, respectively.

Slough Pond. Only the southwest corner inlet poses a problem. Residents have registered complaints in the past to Seashore administrators about the heavy growth of submerged Myriophyllum humile var. natans, and floating Nymphaea and Nuphar which render the cove inaccessible during midsummer months. Moreover, the vegetation of the thickly vegetated shores of this cove includes a rich growth of poison ivy.

Spectacle Pond. Because of its small size and increasingly heavy use by bathers, this pond should be monitored closely for increased presence of pond lilies and other aquatics. The smaller, less accessible pool is already choked with a marsh-bog flora but was most likely never a prime swimming resource.

The remaining ponds that were surveyed, while not having any particularly threatening ²weeK growth in 1978, should be continually monitored for any change.

Duck and Dyer Ponds, however, are especially valuable resources in their clarity and unproductive trophic status. Soukup (1977) refers to Duck in particular as "the most natural and pleasing pond ... a significant resource," but notes an increase in deep water productivity and

decline in water quality since 1958. Data from that time indicated a deep water algal biomass. In this study, plant specimens were dredged from the deepest center regions of Duck Pond. The material included unidentified multicellular algal forms and two to three species of bryophytes.¹ My sampling suggests a significant biomass on the pond bottom at depths of eighteen meters. This profundal flora should also be somehow continuously surveyed for any change.

With respect to the pond vegetation as a resource in itself, the common occurrence of carnivorous sundew plant of the genus Drosera provides a unique and facinating element of the flora. All three species occurring in the northeast United States were found growing along the margins of Cape Cod ponds, although one of the species, Drosera rotundifolia, was scarce and only occurred on Long Pond (see map, east half). The other two types, D. intermedia and D. filiformis, were fairly common along the shores of six and seven of the ponds surveyed, respectively. The extended patch of the two commoner species growing in the sand at the southeast corner of Horseleach Pond is especially extraordinary and should be preserved. The sundews may actually be of current scientific interest in terms of providing prime material for a study in niche partitioning among sympatric plant species.

The ponds of Cape Cod National Seashore are resources deserving of continued Park Service investment in field research with the goal of understanding more fully the nature of currently operating successional

forces. And, if necessary, to initiate steps needed to check the progress of "cultural eutrophication." Continued surveillance of the aquatic and pond-associated flora can help identify and monitor any changes that may occur in the ponds' quality and cleanliness.

The products of this inventory should simplify the efforts of future researchers. Not only is the composition of the flora noted in its entirety for future comparison, but also the existence now of an accessible reference herbarium collection will provide headstart for a botanist unfamiliar with local species in the often painstaking process of identification. The maps are insufficiently accurate for detailed comparison with a later mapping; they do provide a rough benchmark for future notations of the location and growth of major patches of pond vegetation.

SUMMARY

A thorough inventory of pond-associated plant species and a permanent reference herbarium collection of aquatic macrophytes in Wellfleet, MA has been completed. In addition, the presence of significant patches of weedy pondweed growth has been sketched onto outline maps of the ponds.

The distribution of plant species among various ponds was found to reflect the trophic state of the pond community, and changes over

time of the composition of the flora should help indicate progress of successional phenomena. Moreover, growth of pond vegetation was noted to respond to "cultural eutrophication" and provides resource managers with a visible indicator of excessive nutrient input into pond ecosystems. Current locations of such enrichment worthy of management concern appear to be reflected in sites of dense weed growth, and are identified on the maps.

LITERATURE CITED

- Hinds, H.R. 1966. A floristic study of outer Cape Cod, Massachusetts. —
NPS report.
- Godfrey, P. 1976. Plants of the Cape Cod ponds. Univ. of Mass.
NPS/CRU report.
- Phillips, E.A. 1959. Methods of Vegetation Study. Henry Holt Company.
- Polunin, N. 1960. Introduction to Plant Geography. N.Y. McGraw-Hill.
- Randall, W.T. 1976. Vegetation Type Cover Report. Cape Cod National
Seashore. NPS report.
- Soukup, M.A. 1977. Limnology and the management of the freshwater
ponds of Cape Cod National Seashore. Univ. of Mass. NPS/CRU
report #35.
- Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook
of seawater analysis. 2nd ed. Bull. Fish. Res. Bdg., Canada,
167, 310 pp.
- Swan, J.M.A. & A.M. Gill. 1970. The origins, spread, and consolidation
of a floating bog in Harvard Pond, Petersham, Mass. Ecology,
51:829-840.
- Westlake, D.F. 1974. Some basic data for investigations of the
productivity of aquatic macrophytes. in Goldman, C.R.
(ed.). Primary Productivity in Aquatic Environments. Univ.
of Calif Press. Berkley. pp. 231-248.
- Wood, R.D. 1963. Adapting Scuba to aquatic plant biology. Ecology,
44: 416-419.

VEGETATION OF THE FRESHWATER PONDS OF
CAPE COD NATIONAL SEASHORE

Systematic List

CHLOROPHYTA: Charophyceae (Stoneworts)

Chara Schweinitzii

Nitella flexis

Nitella tenuissima

BRYOPHYTA: Musci (Mosses)

Sphagnum spp.

Drepanocladus spp.

CONIFEROPHYTA (Conifers)

Pinaceae (pine family)

Pinus rigida, pitch pine

ANTHOPHYTA: Monocotyledonae (Monocots)

Typhaceae (cattail family)

Typha latifolia, common cattail

Zosteraceae (pondweed family)

Potamogeton capillaceus, pondweed

Potamogeton epihydrus, var. Nuttallii (Nuttall's pondweed)

Potamogeton oaksianus, pondweed (identification tentative)

Potamogeton natans, common pondweed

Najadaceae (naiad family)

Najas flexilis, slender naias; bushy pondweed

Alismataceae (water-plantain family)

Sagittaria latifolia, arrowhead; duck potato; Wapato

Hydrocharitaceae (frog's-bit family)

Elodea Nuttallii (olim. Anacharis occidentalis), water-weed

Gramineae (grass family)

Calamagrostis canadensis, blue-joint

Spartina pectinata, freshwater cord-grass; slough grass

TABLE II

Systematic Listing of the
Vegetation of Freshwater Ponds
of Cape Cod National Seashore

Cyperaceae (sedge family)

- Cyperus dentatus, toothed nut-grass
Cyperus strigosus, nut-grass
Eleocharis Robbinsii, Robbins' spike-rush
Eleocharis pauciflora, spike-rush
Eleocharis acicularis, slender spike-rush
Eleocharis obtusa, spike-rush
Eleocharis palustris, spike-rush
Eleocharis ambigens, spike-rush
Scirpus subterminalis, swaying-rush
Scirpus americanus, American three-square; sword-grass
Scirpus cyperinus, wool-grass
Cladium mariscoides, water bog-rush; twig-rush
Carex longii, broom-sedge
Carex scoparia, pointed broom-sedge

Xyridaceae (yellow-eyed grass family)

- Xyris caroliniana, yellow-eyed grass

Eriocaulaceae (pipewort family)

- Eriocaulon septangulare, white-buttons; duck-grass

Pontederiaceae (pickerelweed family)

- Pontedaria cordata, pickerelweed

Juncaceae (rush family)

- Juncus effusus, soft rush
Juncus pelocarpus, bog-rush
Juncus canadensis, Canada-rush
Juncus militaris, bayonet-rush
Juncus secundus, rush

Iridaceae (iris family)

- Iris versicolor, larger blue-flag

ANTHOPHYTA: Dicotyledonae (Dicots)

Salicaceae (willow family)

- Populus tremuloides, quaking aspen

Myricaceae (wax-myrtle family)

- Myrica pensylvanica, bayberry

Corylaceae (hazel family)

Betula populifolia, gray birch

Alnus serrulata, smooth alder

Fagaceae (beech family)

Quercus alba, white oak

Polygonaceae (buckwheat family)

Rumex orbiculatus, water dock

Nymphaeaceae (water-lily family)

Nuphar variegatum, spatterdock; yellow pond-lily

Nymphaea odorata, fragrant water-lily

Brassenia schreberi, water-sheild

Droseraceae (sundew family)

Drosera intermedia, spatulate-leaved sundew

Drosera rotundifolia, round-leaved sundew

Drosera filiformis, thread-leaved sundew

Rosaceae (rose family)

Spiraea tomentosum, hardhack, steeple-bush

Pyrus (Aronia) arbutifolia, red-chokegerry

Rosa palustris, swamp rose

Leguminosae (pulse family)

Robinia pseudo-acacia, black locust

Aquifoliaceae (holly family)

Ilex glabra, ink berry

Anacardiaceae (cashew family)

Rhus radicans, poison ivy

Aceraceae (maple family)

Acer rubrum, red maple

Malvaceae (mallow family)

Hibiscus palustris, swamp rose-mallow

Guttiferae (St. John's-wort family)

Hypericum boreale, northern St. John's-wort

Hypericum canadense, Canadian St. John's-wort

Hypericum virginicum, marsh St. John's-wort

Violaceae (violet family)

Viola lanceolata, lance-leaved violet

Lythraceae (loosestrife family)

Decodon verticillatis, swamp loosestrife; water-willow

Melastomataceae (melastoma family)

Rhexia virginica, Virginia meadow-beauty

Haloragaceae (water-milfoil family)

Myriophyllum Farwellii, Farwell's water-milfoil (identification tentative)

Myriophyllum humile var. natans, water-milfoil

Umbelliferae (parsley family)

Hydrocotyle americana, American water-pennywort

Cicuta bulbifera, bulb-bearing water-hemlock

Sium suave, water-parsnip

Clethraceae (white alder family)

Clethra alnifolia, sweet pepperbush

Ericaceae (heath family)

Rhododendron viscosum, swamp azalea

Kalmia angustifolia, sheep laurel

Lyonia lingustrina, maleberry

Chamaedaphne calyculata, leatherleaf

Vaccinium atrococcum, black highbush blueberry

Vaccinium macrocarpon, large (American) cranberry

Primulaceae (primrose family)

Lysimachia terrestris, yellow swamp-loosestrife

Gentianaceae (gentian family)

Nymphoides cordata, floating-heart

Asclepiadaceae (milkweed family)

Asclepias incarnata, swamp-milkweed

Labiatae (mint family)

Lycopus uniflorus, bugleweed

Scrophulariaceae (figwort family)

Gratiola aurea, goldenpert

Gerardia paupercula, small-flowered gerardia

Lentibulariaceae (bladderwort family)

Utricularia purpurea, purple bladderwort

Utricularia gibba, humped bladderwort

Utricularia vulgaris, common bladderwort

Utricularia biflora, (identification tentative)

Rubiaceae (madder family)

Galium trifidum, marsh bedstraw; wild madder

Caprifoliaceae (honeysuckle family)

Viburnum cassinoides, witherod; wild rasin

Campanulaceae (bluebell family)

Lobelia Dortmanna, water lobelia

Compositae (composite family)

Eupatorium pilosum, hairy thoroughwort

Eupatorium perfoliatum, boneset

Solidago tenuifolia, slender-leaved goldenrod

Coreopsis rosea, pink tickseed

TABLE III

The Distribution of Vegetation
Among Freshwater Ponds
Within Cape Cod National Seashore

A tabulation of the occurrence
of each pond-associated plant species
in fifteen individual ponds

SPECIES	POND														
	Gull	Higgins	Williams	Herring	Slough	Horseleach	Spectacle	Long	Great (W)	Northeast	Southeast	Turtle	Dyer	Duck	Snow
Nitella flexilis			X	X											
N. tenuissima(?)				X											
Chara schweinitzii(?)				X											
Typha latifolia			X	X										X	
Potamogeton capillaceus	X				X										X
P. epihydrus		X		X											
P. natans							X								
P. oaksianus(?)												X			
Najas flexilis				X											
Sagittaria latifolia	X	X	X	X		X		X				X		X	X
Elodea Nuttallii		X													
Calamagrostis canadensis		X			X	X			X			X		X	
Spartina pectinata						X									
Cyperus dentatus			X						X						
C. strigosus	X			X											
C. spp. (seedling)	X				X								X	X	
Eleocharis robbinsii		X	X							X	X	X			
E. acicularis	X	X	?	X	X			X							?
E. palustris		X		X											
E. ambigens			X												
E. pauciflora					X										
E. obtusa							X								
Scirpus subterminalis											X	X			
S. americanus	X	X		X	X	X		X							X
S. cyperinus		X	X	X											
Cladium mariscoides		X				X	X	X	X						
Carex scoparia			X	X											
C. longii					X									X	
Xyris caroliniana				X	X	X		X	X					X	
Eriocaulon septangulare		X			X	X	X	X		X	X	X	X		X
Pontedaria cordata	X	X		X	X	X		X		X		X			X
Juncus effusus		X	X	X			X		X						X
J. canadensis	X	X	X	X	X				X					X	
J. militaris		X	X			X		X	X				X		X
J. pelocarpus	X	X		X	X			X	X			X	?	X	X
J. secundus					X									X	
Iris versicolor		X	X												

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SPECIES	POND												
	Gull	Higgins	Williams	Herring	Slough	Horseleach	Spectacle	Long	Great (W)	Northeast	Southeast	Turtle	Dyer
<i>Myrica pensylvanica</i>	X				X		X	X					X
<i>Alnus serrulata</i>	X												
<i>Rumex orbiculatus</i>			X	X									
<i>Nuphar variegatum</i>	X	X	X		X	X	X	X		X	X	X	X
<i>Nymphaea odorata</i>	X	X	X	X	X	X	X			X	X	X	Y
<i>Brassenia schreberi</i>		X		X								X	X
<i>Drosera intermedia</i>				X		X	X		X	X	X	X	
<i>D. rotundifolia</i>								X					
<i>D. filiformis</i>						X	X	X	X			X	X
<i>Spiraea tomentosum</i>			X										
<i>Pyrus arbutifolia</i>					X								
<i>Rosa palustris</i>					X								
<i>Rhus radicans</i>	X			X	X			X					X
<i>Ilex glabra</i>							X						
<i>Acer rubrum</i>	X	X	X	X	X	X	X	X	X				
<i>Hibiscus palustris</i>		X											
<i>Hypericum boreale</i>				X		X	X						
<i>H. canadense</i>									X				
<i>H. virginicum</i>	X	X	X	X	X	X	X	X	X	X	X		?
<i>Viola lanceolata</i>		X						X			X	X	
<i>Decodon verticillatis</i>		X	X	X	X	X		X		X	X	X	X
<i>Rhexia virginica</i>								X					
<i>Myriophyllum farwellii</i>			?			X							
<i>M. humile</i>				X	X								
<i>Hydrocotyle americana</i>		X	X	X	X								
<i>Cicuta bulbifera</i>		X	X	X									
<i>Sium suave</i>		X	X	X									
<i>Clethra alnifolia</i>				X	X	X	X	X	X			X	X
<i>Rhododendron viscosum</i>		X	X		X		X	X		X			
<i>Kalmia angustifolia</i>							X						
<i>Lyonia lingustrina</i>			X		X		X						
<i>Chamaedaphne calyculata</i>				X	X	X	X	X	X	X	X	X	X
<i>Vaccinium macrocarpon</i>	X	X		X	X	X	X	X	X	X	X	X	X
<i>Lysimachia terrestris</i>	X	X	X	X	X								X
<i>Nymphoides cordata</i>	X	X			X		X			X	X	X	X
<i>Asclepias incarnata</i>		X	X	X									
<i>Lycopus uniflorus</i>	X	X			?								X
<i>Gratiola aurea</i>	X	X			X	X	X	X	X		X		

Table IV

Kettle Ponds of Cape Cod National Seashore

Ranked in descending Chlorophyll a Concentration (5 April 1978)

	<u>Chlorophyll a</u> (mg m ⁻³)	<u>Specific Conductivity</u> (Mmhos/cm)
Williams	12.2	103
Gull	8.3	n.d.
Herring (outlet)	6.1	95
Kinnacum	5.9	79
Herring (shoreline)	5.4	97
Ryder	3.9	81
Turtle	2.8	74
Horseleeche	2.7	114
Higgins	2.4	n.d.
Snow (,)	2.1	63
Great (T)	2.1	88
Slough	1.9	93
Round (W)	1.6	51
Spectacle	1.4	88
Southeast	1.2	86
Long	1.1	75
Great (W)	0.62	91
Duck	0.49	n.d.
Dyer	0.28	70

Table
APPENDIX 3

Field Maps of Freshwater Ponds
Within Cape Cod National Seashore

A collection of outline maps (scale 1"=200') of fourteen ponds surveyed illustrating regions of densest aquatic macrophytic vegetation. The maps were taken into the field and the plants sketched in "by eye" during the summer of 1978. The original pencil-drawn maps were later duplicated in ink in the laboratory.

Key to Abbreviations

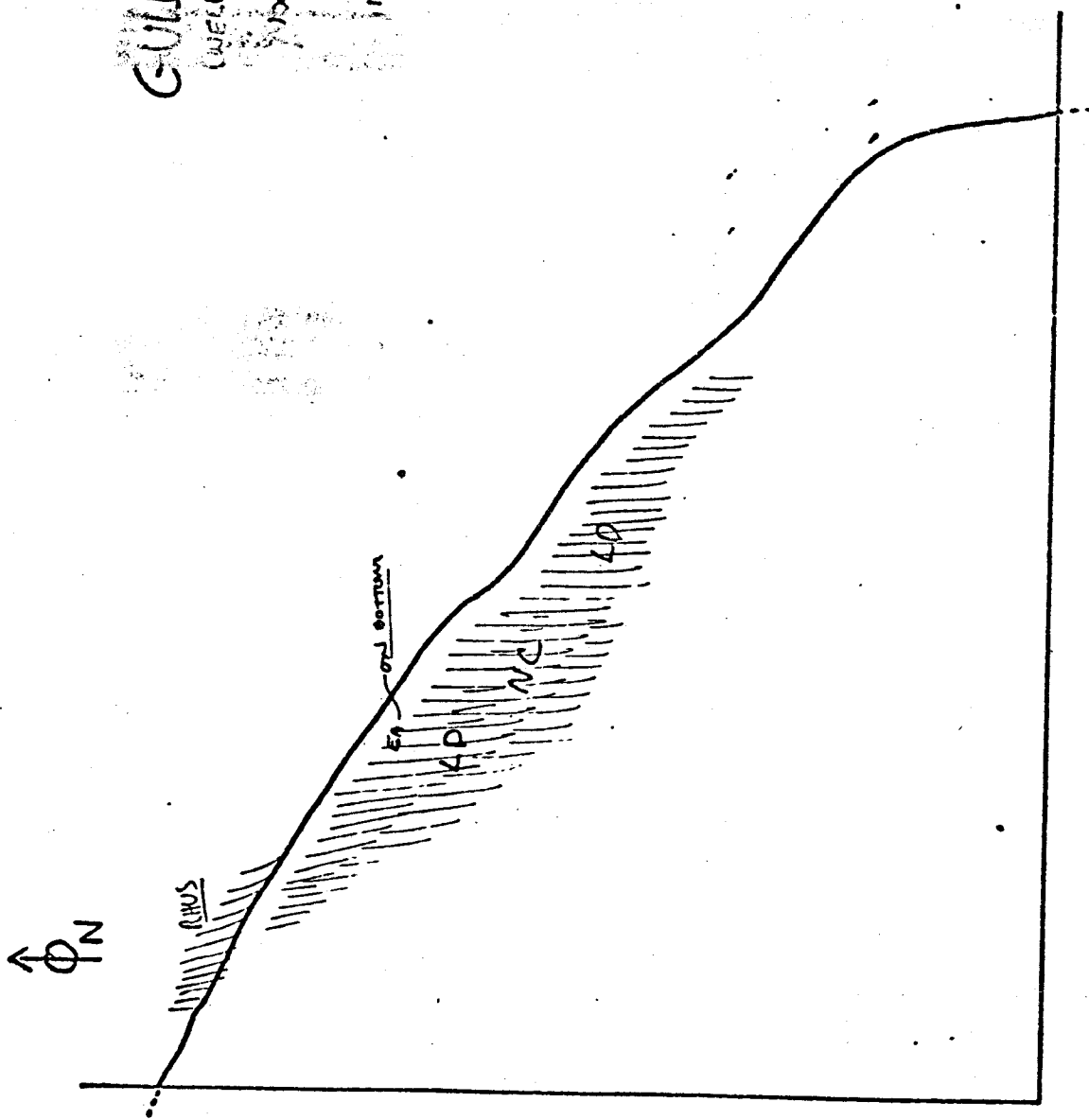
Used to Represent Plant Species in Appendix 3

AI = <u>Asclepias incarnata</u>	JM = <u>Juncus militaris</u>
BS = <u>Brassenia schreberi</u>	JP = <u>Juncus pelocarpus</u>
CCA = <u>Calamagrostis canadensis</u>	LD = <u>Lobelia Dortmanna</u>
CM = <u>Cladium mariscoides</u>	NC = <u>Nymphoides cordata</u>
DF = <u>Drosera filiformis</u>	NO = <u>Nymphaea odorata</u>
DI = <u>Drosera intermedia</u>	NV = <u>Nuphar variegatum</u>
DR = <u>Drosera rotundifolia</u>	PC = <u>Pontedaria cordata</u>
DV = <u>Decodon verticillatis</u>	PE = <u>Potamogeton epihydrus</u>
EA = <u>Eleocharis acicularis</u>	PN = <u>Potamogeton natans</u>
EO = <u>Eleocharis obtusa</u>	SA = <u>Scirpus americanus</u>
ER = <u>Eleocharis Robbinsii</u>	SP = <u>Spartina pectinata</u>
ERS = <u>Eriocaulon septangulare</u>	SS = <u>Scirpus subterminalis</u>
GA = <u>Gratiola aurea</u>	ST = <u>Solidago tenuifolia</u>
HA = <u>Hydrocotyle americana</u>	TL = <u>Typha latifolia</u>
HV = <u>Hypericum virginicum</u>	UP = <u>Utricularia purpurea</u>
JC = <u>Juncus canadensis</u>	
JE = <u>Juncus effusus</u>	

GULL POND
(WELFLEET, MA)

SOUTHEAST
QUADRANT

$H = 200'$



GULL POND
(WELFLEET, MA)

NORTHWEST QUADRANT

1" = 200'

AN
Φ

HIGGS

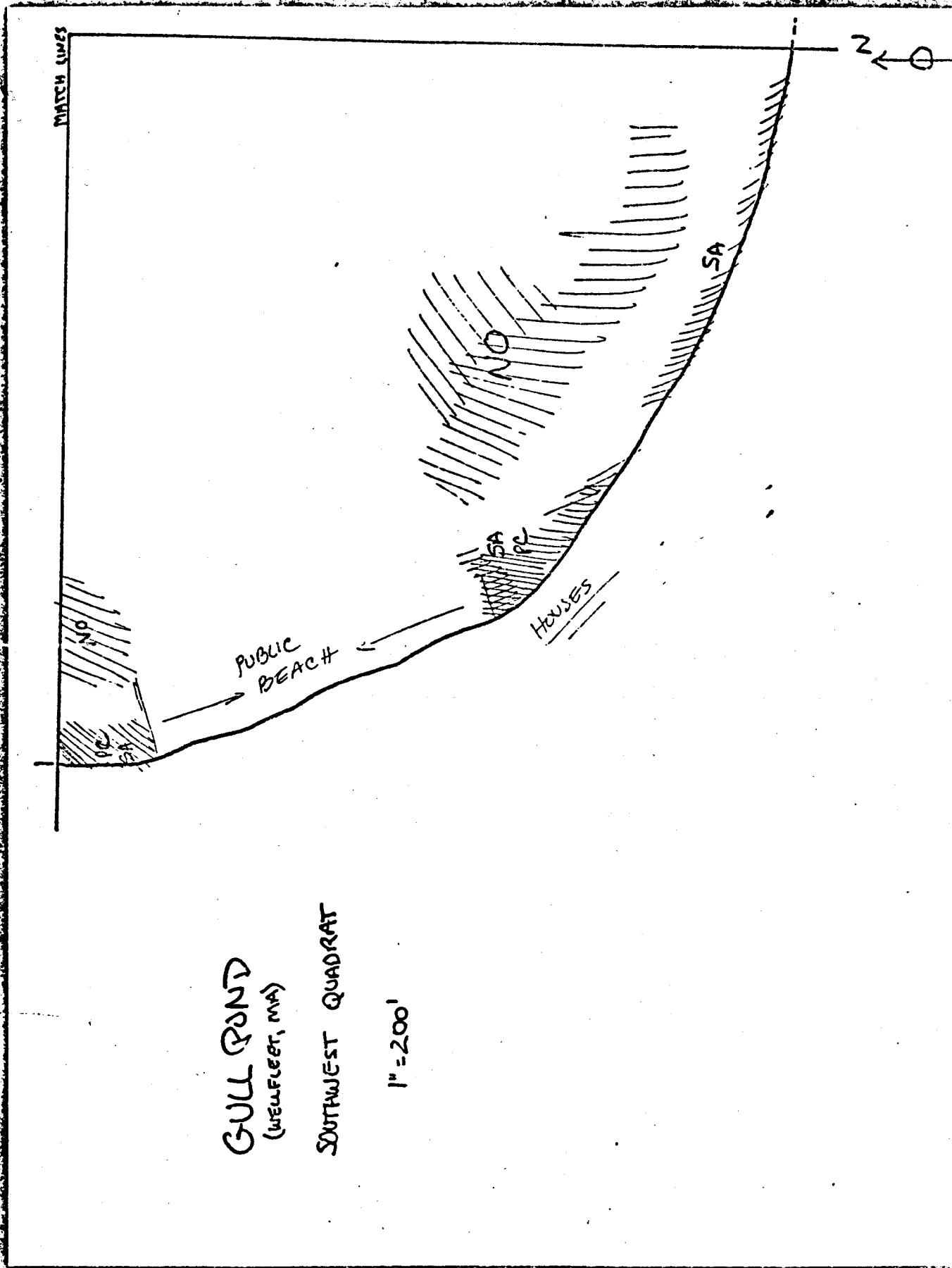
9A
11"

ANUS
SEALANT
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
NO

GULL POND
(NEWFLEET, MA)

SOUTHWEST QUADRAT

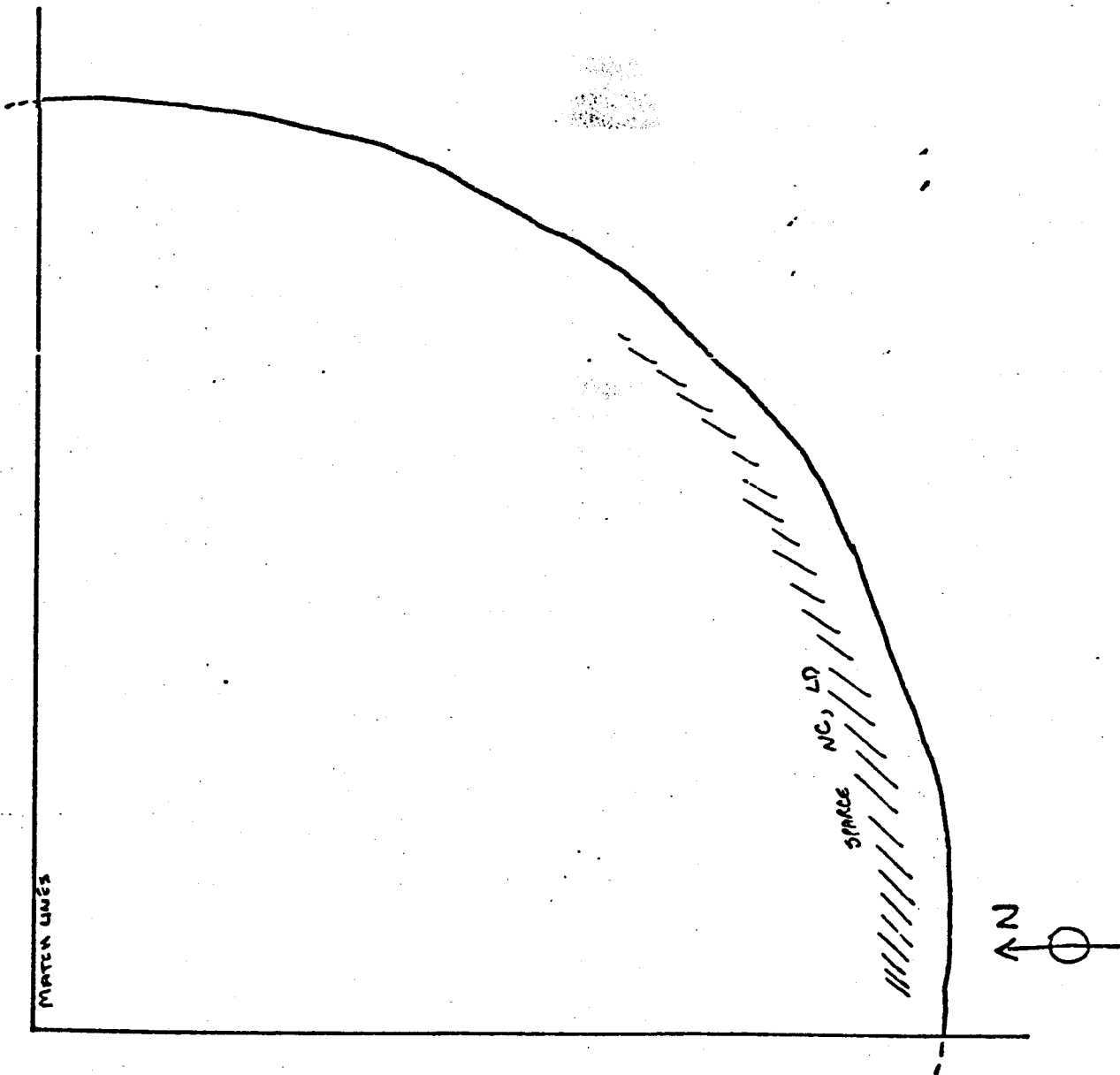
1" = 200'



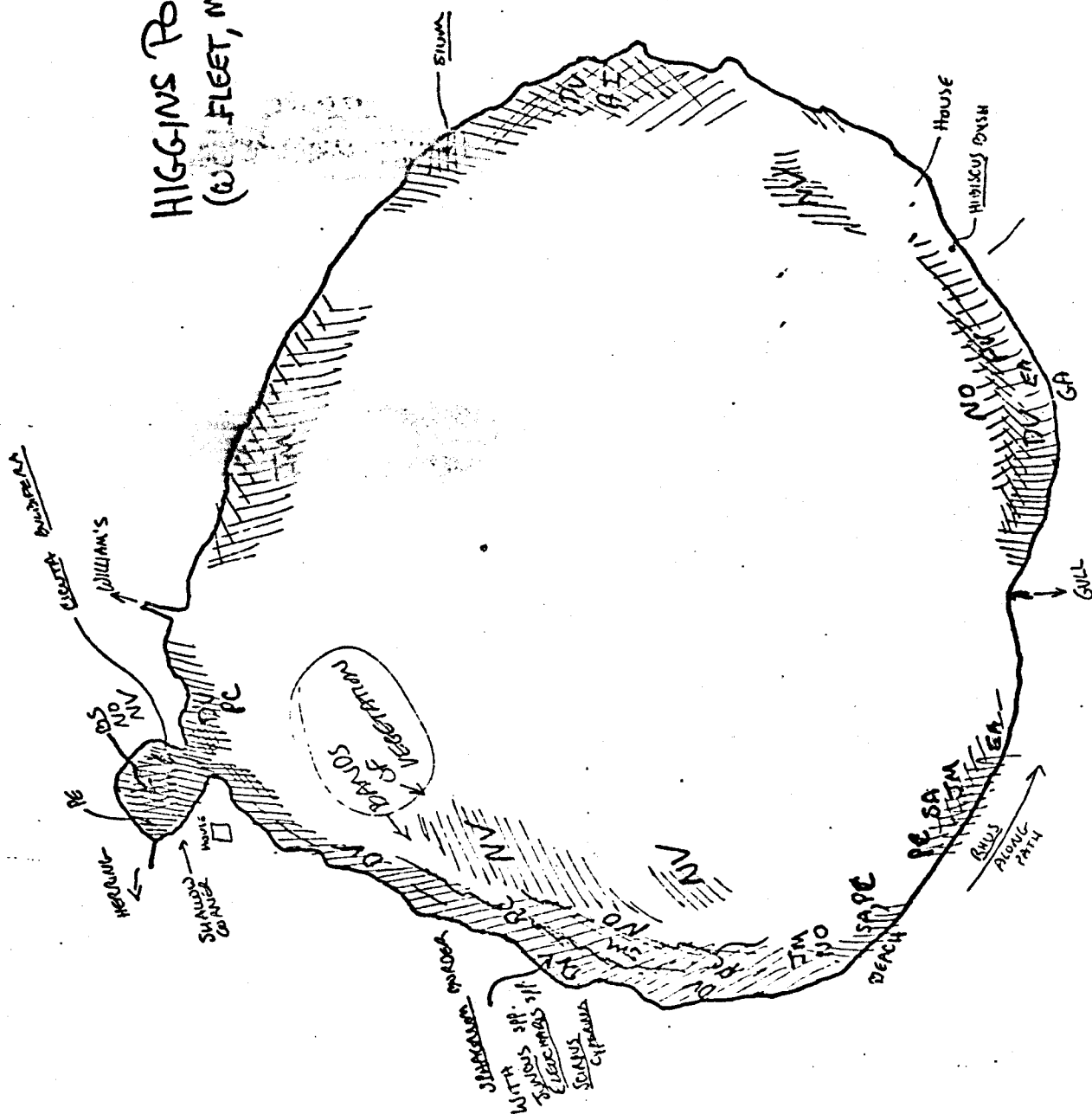
GULL POND
(WELFLEET, MA)

SOUTHEAST QUADRANT

1" = 200'

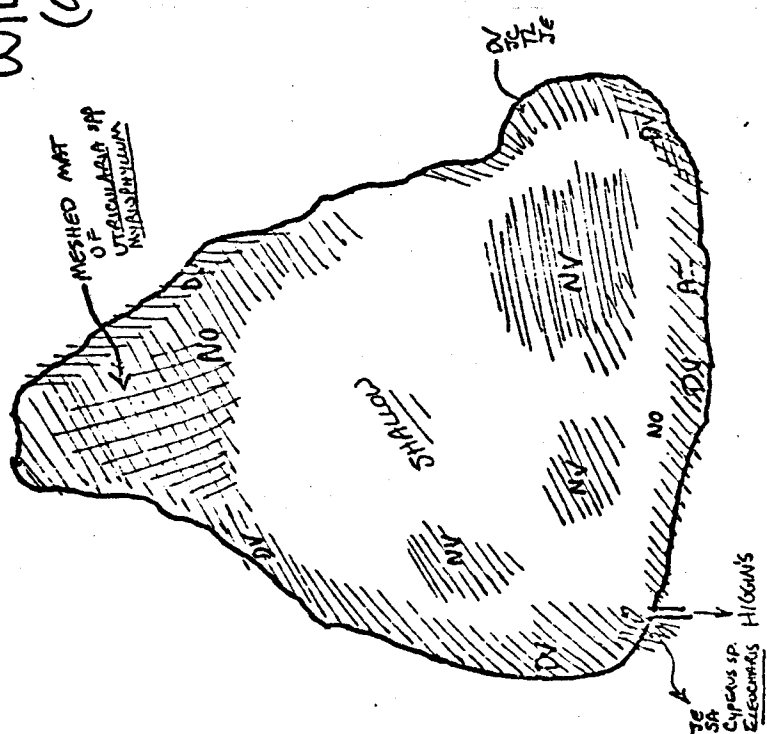


HIGGINS POND
(W. FLEET, MA) 1" = 200'



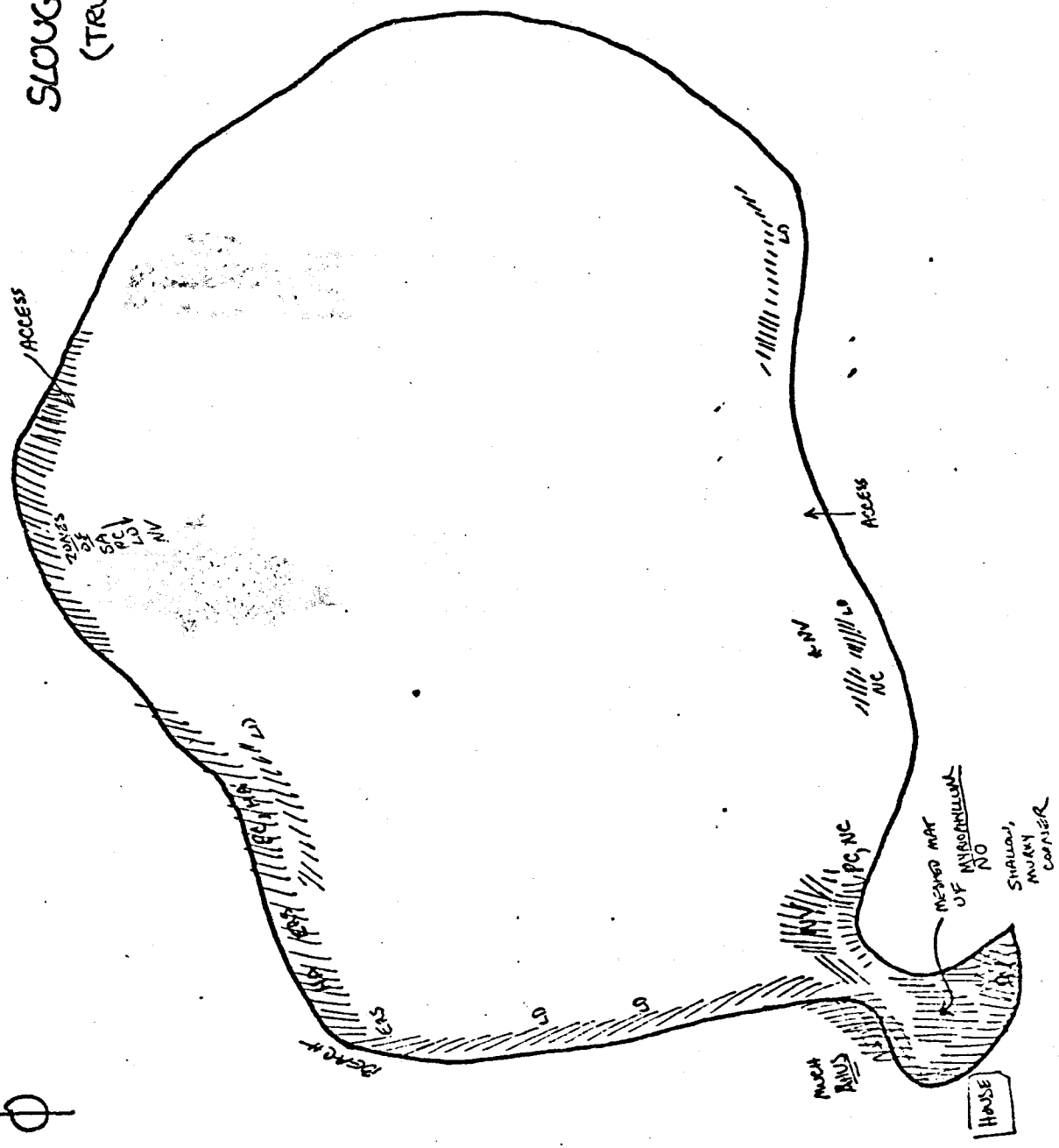
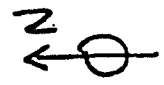
N
Φ

WILLIAMS POND (WELFLEET, MA) 1" = 200'



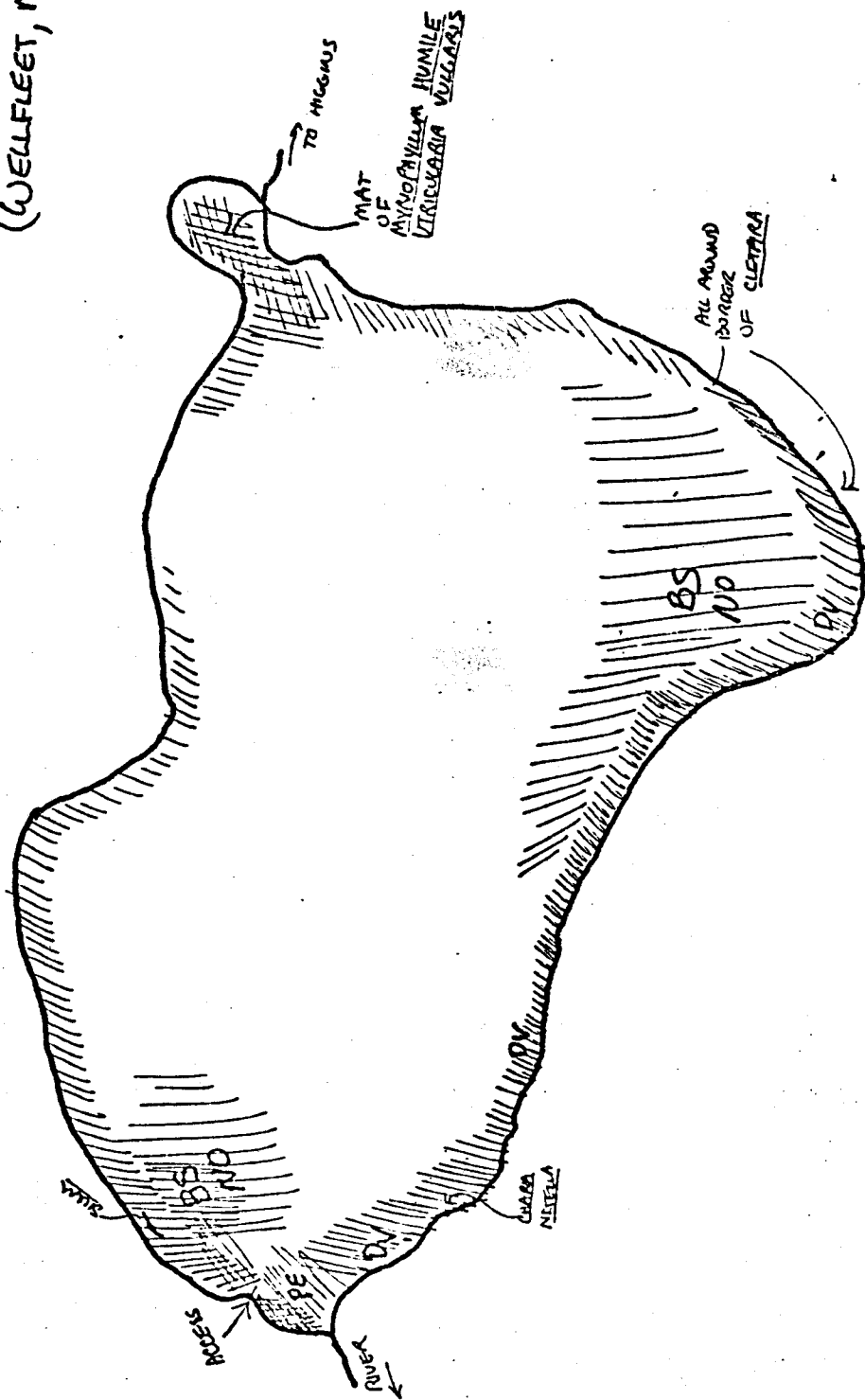
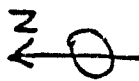
SLUGH POND (TRURO, MA)

1" = 200'



HERRING POND (WELLFLEET, MA)

1" = 200'



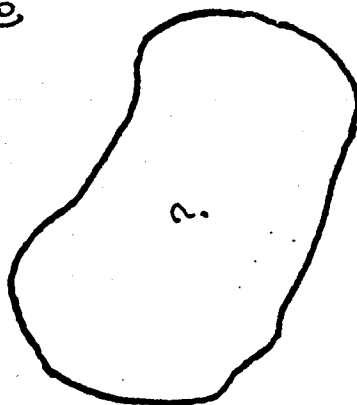
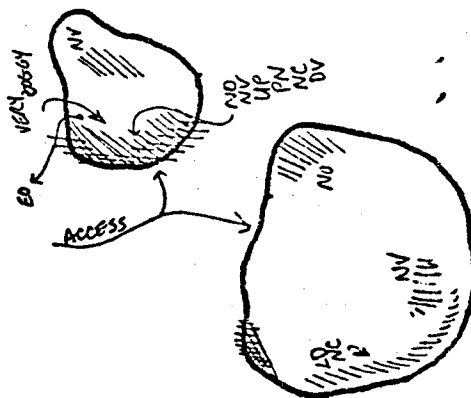
2.

KINNAMOM POWD
(or LUMPKIN'S)

and

SPECTACLE POND

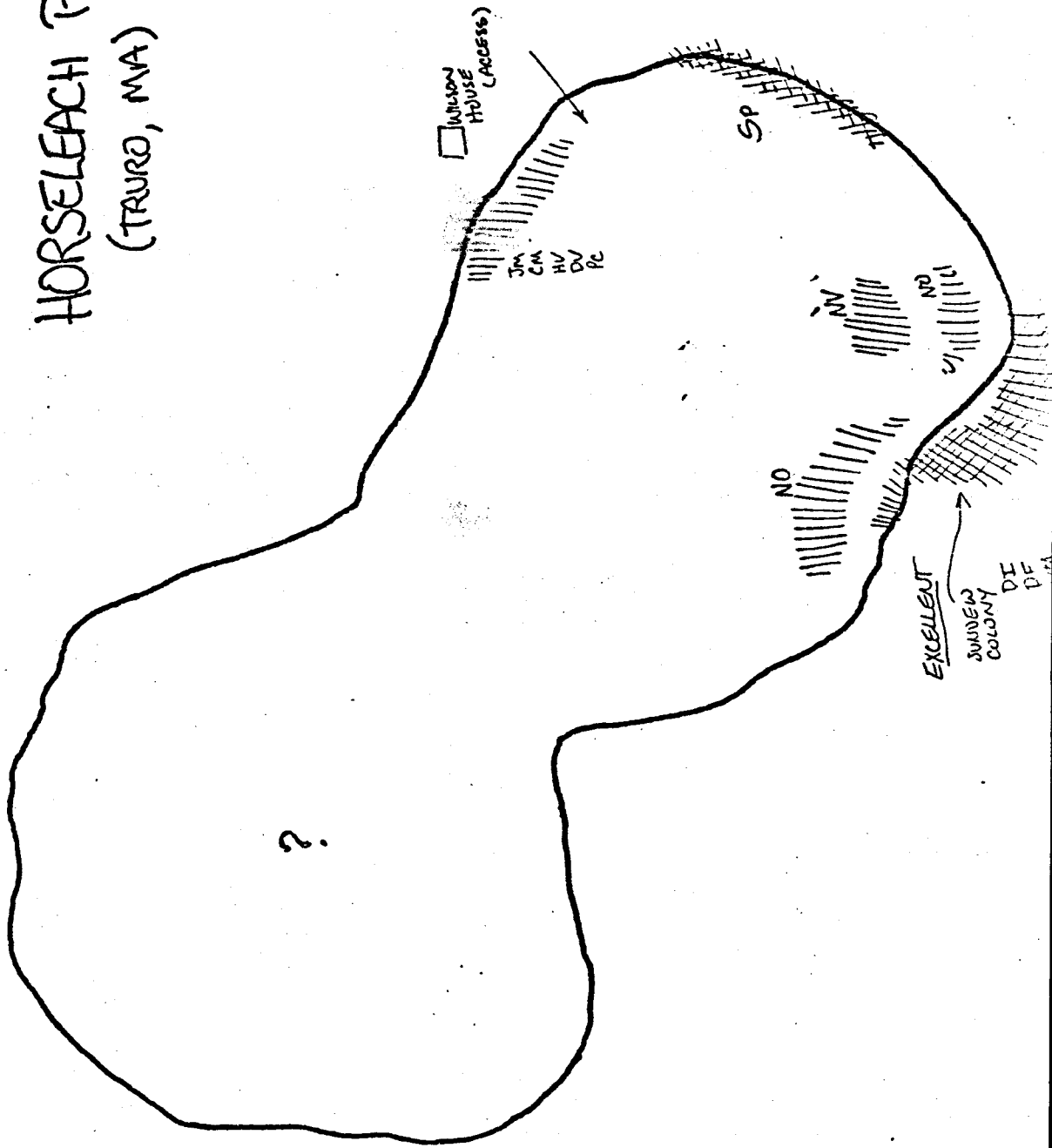
(WELFLEET, MA)
11 = 200'

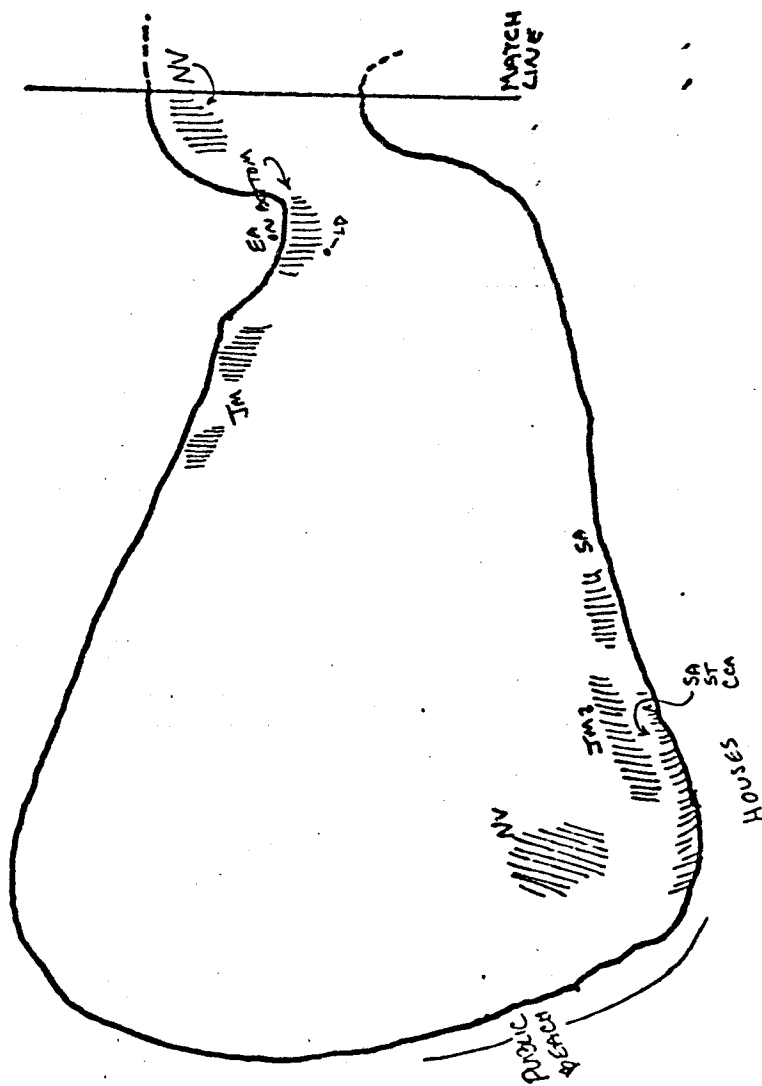


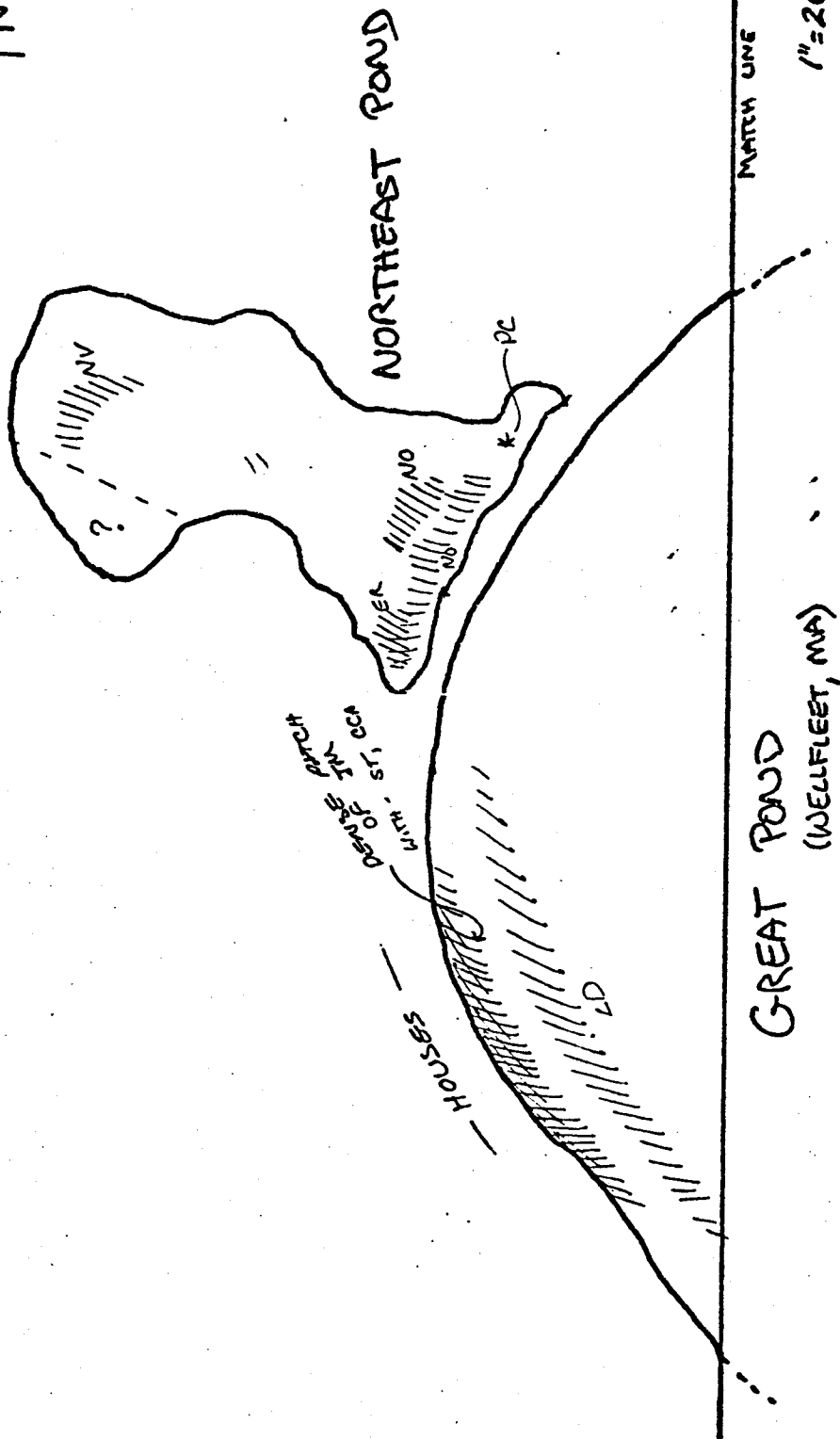
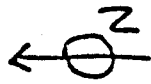
↑ ϕ_N

HORSELEACH POND

(TRURO, MA) 1"=200'



$$\begin{array}{c} 2 \\ \leftarrow \ominus \end{array}$$




$$\overset{2}{\leftarrow} \bigcirc$$

MATCH LINE

$l'' = 200'$

SOUTHEAST
POND

EA

142675

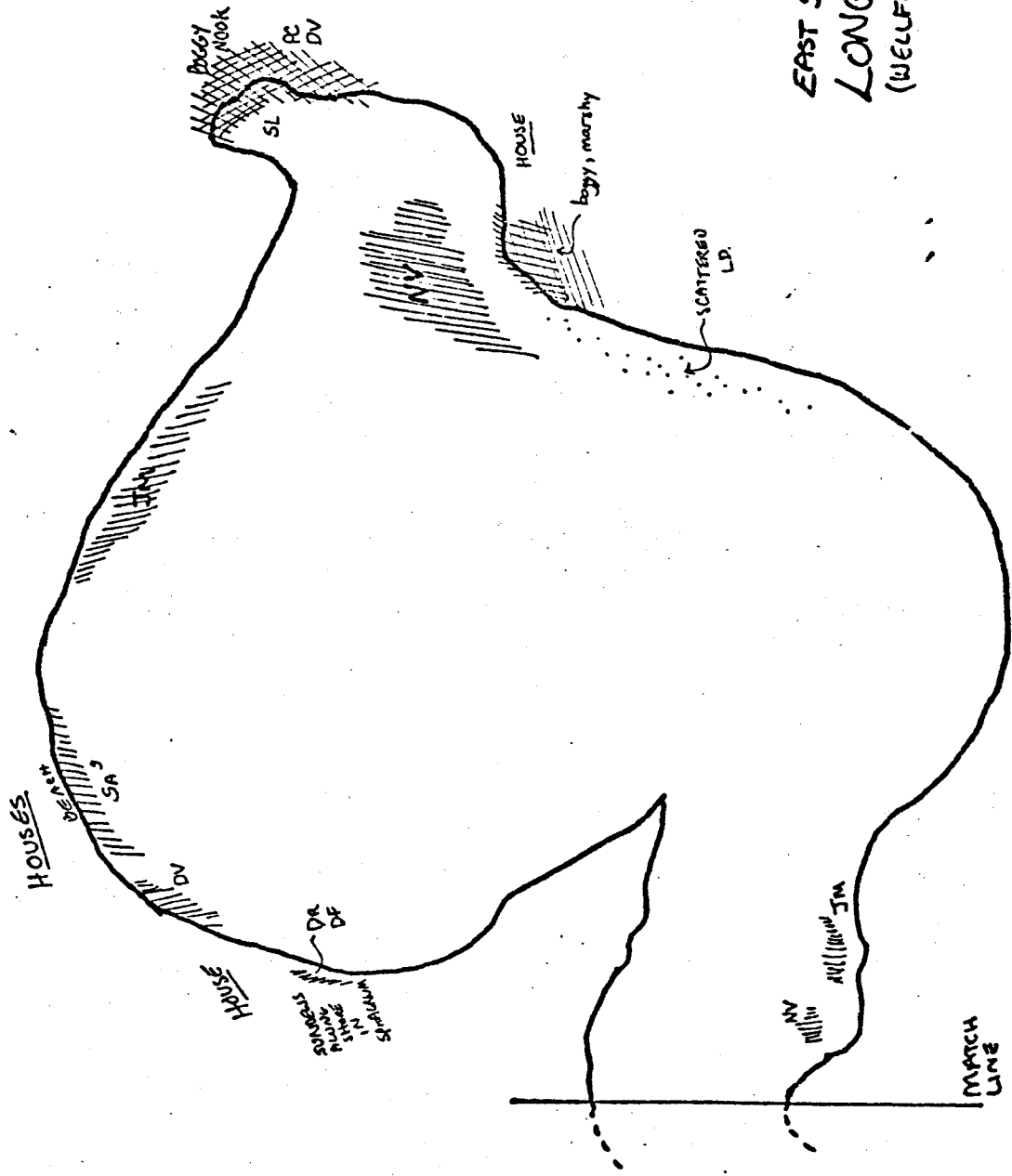
5/10/55

turn
fund



EAST SIDE OF
LONG POND
(WELFLEET, MA)

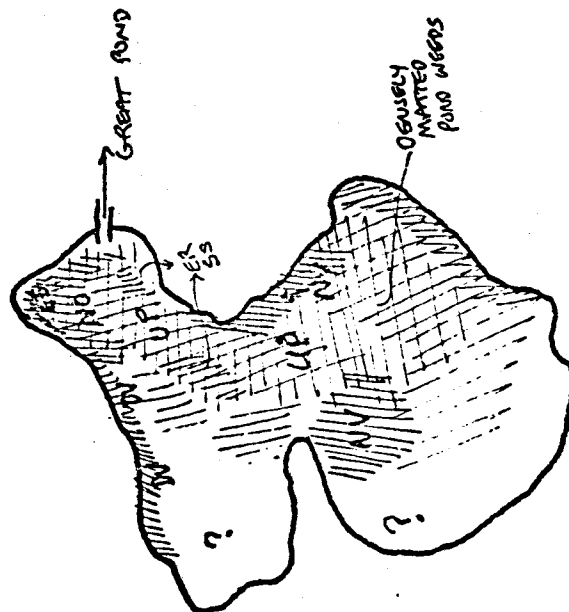
1" = 200'



TURTLE POND (WELLFLEET, MA)

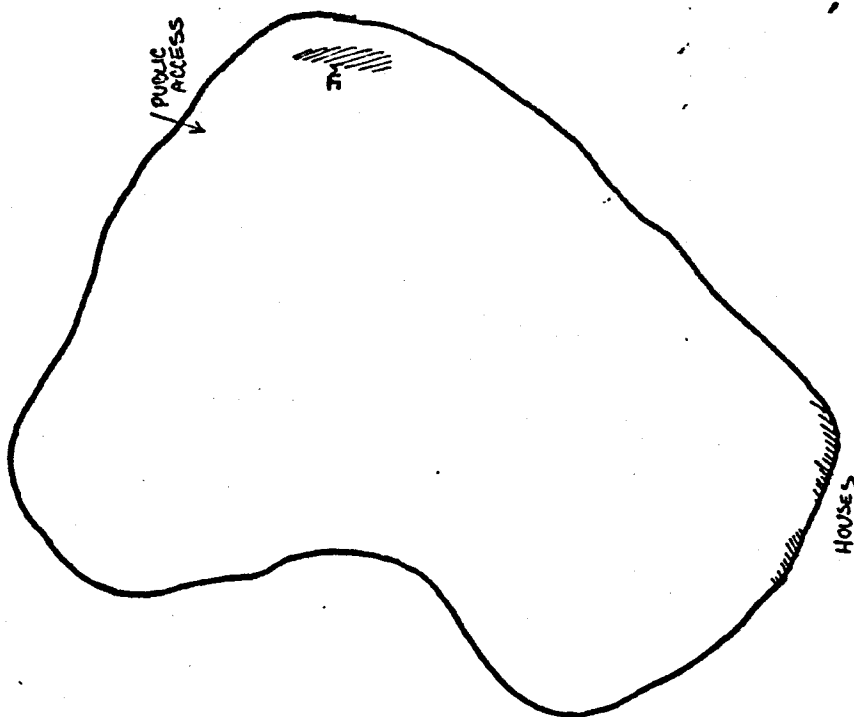
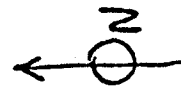
1" = 200'

↑ N



DYER POND
(WELLFLEET, MA)

1" = 200'



DUCK POND (WELLFLEET, MA) 1" = 200'

2
φ

